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A NOVEL PILE DRIVER (see page 391)

Surveying and Mapping from Airplanes*

How Recent Experience in War Mapping May Be Applied in Completing Our Topographic Map

By Col. E. Lester Jones, Sup't U. S. Coast and Geodetic Survey

THE aeroplane, while not a product of the war, owes its present very prominent place to the war, and if it had not been for the war its development would have been retarded many years. It had few practical uses from the time Wright Brothers first flew their machine at Fort Myer, in 1909 until 1914. They were popularly regarded as playthings to amuse the holiday crowd.

The war changed this situation. The Allies and the Central Powers almost immediately saw the great importance of the aeroplane in battle and the best brains and energy of the warring nations were given to the problem of making the airplane perform what a few years ago would have been considered miraculous things.

War planes were made for various purposes, which I need not enumerate. But the most important thing done from the aeroplane was photographing the enemies' lines and thereby discovering the positions of the batteries, ammunition dumps, the truck systems and other military facts and features.

The same methods, with some modifications, are now being considered in connection with the mapping of extensive areas by the map-making organizations of the country. In fact, some work has already been done and experiments are being carried on which promise excellent results.

There is so much misinformation regarding surveys and maps, that it seems appropriate for me as the head of the oldest map-making bureau of the government, to present the topographic situation to this Congress, both for your information and as a matter of record.

Surveying and mapping have long histories and the development of the methods now employed took centuries. But the method of airplane surveying has developed like a mushroom. To what extent is it applicable to our needs? This I shall endeavor to show.

In collecting data for a map those surveying methods must be adopted in any particular case that suit the requirements. If one should wish only a route map running from one village to another, it would be perfectly satisfactory to use a compass for direction and the pacing of a horse or the readings of an odometer on a wheel for the distance between the two points. But maps are usually not so simple as that.

TYPES OF MAPS.

There are several types of high grade maps needed in the country. One must be made along the coasts to show the location of the actual shore line and the character of the ground immediately back of the coast in order that the navigator may be able to locate himself from topographic features along the shore, should he be driven off his course during a storm. In addition the depths of the water and all obstructions to navigation must be indicated on this map or chart, the elevation and shape of the ground on islands and just back of the coast must be shown on the map by contours.

A second class consists of maps on which the features other than elevations and contours are shown in their correct horizontal positions. This type of map would be practically the same as the third type where the area covered is very level. Such an area would be the coastal plain of Louisiana.

The third class covers maps of the interior or of large islands on which all features, cultural and natural, are located in their proper horizontal position and contours are shown to give the elevations of the ground and the shape of the hills, ridges, valleys, etc. This map would be used by engineers in laying out railroads and highways, and in conducting various classes of engineering work.

These three classes of maps are the ones in which we are most directly interested.

The map which shows the horizontal positions of cultural and natural features on the surface of the earth but no contours can be made more rapidly than the one which requires contouring. All that is needed in the former case is some method of obtaining the direction and distance between each two features in the area to be surveyed. The usual method of making such a map is by compass and chain or by transit and tape or transit and stadia or by the plane table. These methods are all very closely allied and such accuracy as may be demanded may be obtained by varying the methods used.

MAPS CONTROLLED BY FIXED POINTS.

In any event there must be within the area to be surveyed, if it is a large one, a number of control stations. These control stations consist of triangulation stations placed on the highest parts of the ground or traverse stations which may be along the roads, which are accurately located in latitude and longitude and which are accurately and substantially marked with concrete or rock in order that they may be recovered and identified by any surveyors or engineers who wish to use them.

There are now many thousands of such stations in the United States, established principally by the Coast and Geodetic Survey, available for the fundamental control of surveys and maps. From the stations established by that Bureau control of the same or of a lower grade of accuracy may be extended in any direction for the immediate control of topographic maps.

OVERLAPS, GAPS AND OFFSETS TO BE AVOIDED.

It is readily seen that without the fundamental control, which extends over the whole area of the United States, there would be great confusion. If the control in any one State is not properly co-ordinated and correlated with that of any other State near it, the result will be that when different topographic surveys and maps are joined there will be overlaps, gaps and offsets which cause no end of trouble and confusion to the cartographer and map maker. When there is a single system of control for the whole country we avoid this unfortunate condition.

3,000,000 SQUARE MILES—LESS THAN ONE-HALF MAPPED.

There is today only about 40 per cent. of the 3,000,000 square miles of the United States mapped both as to horizontal positions of the features and the elevations by contours of hills, ridges, valleys, etc. These are the maps of class three, mentioned previously. Some of the 40 per cent. of the surveyed area will have to be resurveyed because the original work was done many years ago when methods were not as refined as they are today and the demands of map users were not as exacting as they are at present. It is safe to say that not over 30 or 35 per cent. or one-third of the whole country is adequately mapped.

The question is, what shall be done with the other 60 per cent. This is a question that is puzzling map makers constantly and no ready solution is at hand provided we insist on having a map of the whole area within a few years.

It is possible that here may be a valuable field for the aeroplane. It is not believed that the aeroplane unsupported by other surveying can give the final accuracy required in original surveys. But by its means can be made a map that will be much better than the maps which may be in existence today in the areas which have not been topographically mapped. In order that the remaining 60 per cent. of the country might be mapped by aeroplane it would be necessary to have a great amount of triangulation and traverse run with a view to furnishing the horizontal control for the photographs to be made by the aeroplane. With this control, it would be possible to fit the photographs on the map into their proper positions.

AEROPLANE SURVEYING WILL DEVELOP.

It is not possible to run many miles with aeroplane photographs and expect to have a very high degree of accuracy in the resulting maps and here I wish to give a word of caution to the advocates of aeroplane mapping, that everything cannot be expected of aeroplane mapping. The development of this science will undoubtedly be rather slow for a few years. After it has been developed methods must, of course, be thoroughly tested before they can be adopted. It is well that this is so for otherwise haste might cause mistakes which would discredit the method to such an extent that it would take years to recover.

CHARTS OF THE COASTS.

The first class of maps considered here consists of charts of the Coast and Geodetic Survey which show the level area immediately along the coast and the water area for some distance out from the shore. The purpose of coast charting is to furnish a safe means of communication by vessels along the coast or in approaching the coast. At present, the methods employed are the usual ones for the topographic surveying of the shore line and the area immediately back of it and the ordinary hydrographic methods of surveying in the water.

The coast line of the United States has been mapped, but the currents and waves of the oceans cause many large changes in the shore line. In the case of Fire Island entrance, Long Island, New York, this was changed in position about four miles in fifty years. The changes are so rapid that frequent resurveys of the coast must be made to furnish exact and reliable information to the navigator. It is also necessary to revise the area just back from the coast, for roads are frequently changed in position or abandoned, new ones are established, houses are built or burned, villages spring up, woods are removed or grow over what were vacant fields at the time the map was made and all of these changes should be shown for the use of the mariner. The question arises as to how such revision shall be made.

REVISION OF CHARTS BY AIRPLANES.

From the experience of the engineers of the Coast and Geodetic Survey the revision of an area that does not need contouring is almost as expensive and takes almost as much time as the original survey, for it is necessary to make a test of the position of each feature. It is here that the aeroplane will be of the greatest service, for if a portion of the shore line should be inspected with a view to learning whether or not the map of it should be revised, we could have a series of photographs made by an aeroplane along the coast, and a comparison of the photographs with the original map would enable one to locate very definitely each area within which there are new features or where old ones have changed. It is believed that in most cases the details on an airplane photograph could be placed on the map from the photograph with all of the accuracy that is needed in the topography shown on the coast charts.

It is a debatable question as to whether the aeroplane photograph made over a water area will show any outline of dangers to navigation when the plates are developed. If they are shown, there is a vast field for the aeroplane in making photographs over water areas where it is known that many obstructions exist. With the usual surveying methods, it is difficult at times to locate every obstruction. One or more on any chart might be missed. The fact has been proved a number of times in a most disastrous way by vessels running on uncharted rocks both along our eastern and our western coasts and especially in Alaska.

The Coast and Geodetic Survey is now making wire drag surveys of all doubtful areas along the coast but it will be many years before the bureau can assure the navigating public that all obstructions have been found and accurately charted.

AEROPLANES AND HYDROGRAPHIC SURVEYS.

It may be possible that an aeroplane photograph will indicate submerged rocks or other dangers that are close to the surface of the water. It would be a question of differences in shade in the photograph. If such a detection of danger can be made then one must be very cautious to make the photographs only on perfectly clear days. Otherwise, the cloud passing over makes its shadow on the water which might show on the photograph and cause uncertainty as to whether the spot is a cloud or an actual obstruction.

There are many hundreds of square miles of area along the coast that consist of salt marshes with many streams of little or no importance but which should be shown in their proper relation to other topographic features. These marshes can be photographed from aeroplanes and the streams running through them would probably show in such a way that they could be fitted into the map from the photograph. Here might be a large saving of time for the surveyor in the field.

There are other cases where there are extensive mud flats, when the tide is low, as in Jamaica Bay, New York. To survey the outline for these flats is rather laborious, with the usual instrumental methods, but it is believed that it might be possible to photograph them from an aeroplane and have the results placed on charts. It will undoubtedly be possible to get these located on the charts from aeroplane photographs with all the accuracy that is necessary for the navigator.

*Address before Second Pan-American Aeronautic Convention, Atlantic City, N. J., May, 1919; contributed by the author.

LOCATION OF DANGERS TO NAVIGATION.

In making photographs from the water, for the purpose of discovering obstructions to navigation at low tide it will be necessary to have some means to properly locate photographic features on the chart. This probably can be done by anchoring two or three small boats within the area of the photograph and locating them with relation to triangulation stations. The location could be done in the usual way in which the sounding boat is today given its position, that is by taking two sextant angles simultaneously from a boat to three control points. It can readily be seen that if two or three accurately located boats are clearly shown on the aeroplane photograph, it will be possible to place the topographic details on the map in their proper positions.

I do not wish to convey the idea that the aeroplane photography will supersede the usual methods of hydrographic surveying, but it would supplement those methods by making it possible to discover channels running through mud flats, also coral heads, shoals, and other obstructions which might be close to the surface of the water and which may be missed by the usual methods of conducting hydrographic surveying.

There has been a rather positive statement made above that the aeroplane can be used to advantage in the work of the Coast and Geodetic Survey. This is undoubtedly true but only time and the development of the methods can show just how much the aeroplane can be used by this Bureau.

THE AEROPLANE IN TOPOGRAPHIC MAPPING.

We now come to the third class of maps and that is a subject on which I hesitate to express an opinion. That is the mapping of the interior of the country. This work is undertaken by the U. S. Geological Survey, supplemented to a certain extent by the Corps of Engineers, U. S. Army. The Coast and Geodetic Survey co-operates with those two organizations to the extent of furnishing the fundamental horizontal and vertical control for the surveys and maps but almost all of the actual location of artificial or natural features is done by the other organizations. It is understood that the officers of those two organizations have given consideration to the question of map-making by aeroplane photographs. It is hoped that aeroplane surveying can be developed at least to supplement the usual surveyor's methods in mapping the interior on a comparatively large scale map with high accuracy.

It would appear that if the aeroplane photograph will be of so much assistance in the topographic work along the shores of the country that it would really be of some value in the interior.

Whether or not it is possible to make contours from aeroplane photographs is a question that has not yet been decided. Many persons who have studied the question claim that it is impossible to locate accurately contours from aeroplane photographs. Others claim that they can be located with great accuracy. The chances are that some mean position will be found to be the true one. It is possible that the stereoscopic method can be applied to two photographs taken by two cameras on the same aeroplane or by cameras on two different aeroplanes together to obtain a rough idea of the configuration of the country.

SURVEYING THE INTERIOR OF THE COUNTRY.

With regard to surveying the interior of the country for the purpose of making an accurate large scale, contoured map, I may say that here the aeroplane photographs can undoubtedly supplement the usual surveying methods, but cannot entirely supplant them.

Such a map should probably be on a 1/50000 scale, that is one foot on the map would equal 50,000 feet on the ground, and the distance between control points on the opposite edges of the area of a map should be correct within about 1 part in 10,000. The only method by which this can be accomplished is that of triangulation and transit and tape traverse.

The method today is to establish the triangulation and traverse stations ahead of the topographic surveying, with the geographic positions, that is latitude and longitude, computed on the North American or final datum. When the control points are placed on that datum their positions will not have to be changed when two maps are joined.

The control, that is triangulation and traverse, bears the same relation to the topographic mapping of the country that the steel frame work of a sky-scraper bears to the detailed portions of the building, such as walls, floors, doors, windows, etc. If the steel work is not accurately fastened and adjusted when erected, before the detailed portions are started on a building, it is reasonably certain that the building will be distorted in shape and will be structurally weak.

The same idea pertains to maps, and the difficulty mentioned actually exists today in some parts of our country, where the detailed mapping of certain areas had to precede the triangulation and traverse on the North American datum. The results have been overlaps, gaps, offsets, etc., when two maps, based on different datums have been joined together.

LATITUDES, LONGITUDES AND ELEVATIONS NEEDED.

It is the province of the Coast and Geodetic Survey to extend the fundamental control that is latitudes and longitudes throughout the country in long arcs. These arcs are interlaced in order that the requisite strength may be obtained. This work has been carried on as vigorously as the funds at the disposal of the Survey would permit. We have arrived at a situation today which demands that this work be exploited, and it is hoped that Congress will respond to our appeals for funds in order that the work may be carried on so rapidly that all mapping operations of Federal, State, City, County, and private organizations, may have their needs met. This is a very urgent matter and I shall do my utmost to persuade the authorities to give this branch of Federal surveying ample support, in order that the country may be mapped more satisfactorily and more efficiently.

When this control is available in any area, the usual method is to have surveying parties in the field place the topographical features of the maps in their proper relation to the control points. Every object on the face of the earth has one, and only one position, and it is the duty of the surveyor to place that object, whether it is a road crossing, a bridge, the top of a hill, or any other object, in its proper position on the map. On the most exact map for military purposes a well defined feature is placed on the map within 30 feet of its exact relation to the nearest control station. Other maps have larger allowable discrepancies.

The work involved in the topographic surveying consists not only in placing the features on the map in their correct horizontal positions, but it is also necessary to show by contours, the lines of equal elevation, the slopes of the ground, the shapes of hills and the exact elevations of a number of critical points.

The elevations are based upon lines of levels run inward from the oceans. The surface of the ocean, if it were at rest would be a continuous one and thus the mean position of the surface serves as a datum plane from which to measure heights in the interior of the country. More than 40,000 miles of the highest grade leveling has already been established in the interior of the country, and there are more than 20,000 precise leveling bench marks whose elevations are known within a very small portion of a foot.

In addition to the above there are many thousands of miles of leveling of a lower grade of accuracy which is used for the immediate control of the topographic surveying.

It is the duty of the Coast and Geodetic Survey to extend the lines of precise leveling into the interior of the country for the purpose of furnishing starting points for the leveling needed for the immediate use of the surveyor and engineer.

What has been said in regard to the fundamental horizontal control is also applicable to the precise leveling. Many more thousands of miles of this grade of leveling are needed in the United States today and it is hoped that my Bureau may be given the support necessary to complete that work, or so much of it as is immediately needed within the next few years.

TOPOGRAPHIC SURVEYING WITH PLANE TABLE.

The topographic surveying is done generally by means of the plane table which consists of a tripod and certain fixtures and a plane board mounted thereon. The board is approximately 24 x 30 inches in horizontal dimensions. On this board is placed a sheet of paper on which the topographical features are shown. On the paper there will have been placed before going to the field, the positions of the control points, and with these as starting points, the topographer weaves a net showing the various features of the earth's surface by means of symbols. These symbols have been standardized by the map users of the United States. Any one using one of the high-grade maps should be thoroughly familiar with the symbols in order that he may make far greater use of the map than if he were ignorant of many of them.

It seems to be absolutely necessary in making the contoured survey, to do the work with the present methods. One can readily understand that it would be impossible to show contours at intervals of 20 feet (that is the difference between two contours will be that amount) over a wooded area, where trees in different parts of the forest varied in height. The aera photographed will not show the differences of elevations of trees in a wood, for the low trees and bushes not more than 20 feet in height, would show about the same on a photograph as a primitive forest where the trees may be 70 to 100 feet high.

ENGINEERS NEED ACCURATE MAPS.

The contoured map must be of such accuracy as to enable the highway engineers, and engineers engaged on irrigation projects, to lay out their work accurately. It can be readily seen that with an accurately contoured map, the engineer could plan the railway, the highway, etc., from one place to another, and not make great mistakes in grades and alignment. It is believed that this would be impossible from a contoured map made from aero-photographs. It is possible that some method may be discovered by which the differences in elevation between two points shown on each of two separate photographs can be computed, but if one considers that the work involved, if it can be done at all, will be very great, he will see that it will probably be more economical to put the contours on the map by the usual methods than to compute innumerable elevations from photographs.

The possible method of computing distances and elevations from photographs may be supplemented by using the stereoscopic method which would give one an idea of the configuration of the ground. This would enable the draftsman in the office to select critical points whose elevations could be determined. Such critical points would be crests of hills or ridges and the bottoms of slopes. If the elevations of critical points are determined then contours could be interpolated between them.

I am giving these statements with a good deal of reservation on my part, for the method of contouring by aeroplane photography has not been developed and it may be that very little can be accomplished where accurate contouring is desired.

AEROPLANE SUPPLEMENTS PLANE TABLE.

But this accurate large-scale contoured map can undoubtedly be made by combining the usual methods of surveying with the aerophotographs. The aerophotograph will usually give a great deal of detail which may facilitate the progress of the map by the topographer to select a number of definite points on his map, such as road crossings, large buildings, groups of buildings, bridges, and other features which can be identified from the photographs. Those features would serve as control points for the topographic details shown on the photographs. Without such points located by the usual methods, it would be necessary to place certain conspicuous objects on the ground near the triangulation and traverse stations. Most any kind of object that would show in the photograph, and have a distinct shape, could be used. But the placing of these objects would be expensive. It is believed that the location of the conspicuous features referred to above could be done by the topographer at a much smaller cost than the cost of placing objects for the aerophotographs, at the triangulation and traverse stations.

It is possible that the topographer would be able to place the topographic details on his map from the photographs before going into the field to do the contouring. Much of the work of the topographer by the usual methods consists in placing the topographic features on the map in their proper location, but a great deal of this might be obviated by the use of the photographs. Then he could go into the field and place the contours with greater rapidity than if he attempted to do so previous to using the details of the photographs.

AEROPLANE VALUABLE FOR MAP REVISION.

What I have stated above in regard to original surveys by aero-photography, in the three classes of high grade maps, are simply opinions or prophecies. These are the coast charts, the contoured maps of the interior, and maps which show all features except contours, but I feel confident in stating that even on the highest grade of topographic maps, the aerophotographs can be used to a great degree in revising and bringing up to date maps of that character which have already been made. Let us suppose that we have before us a topographic map made by the U. S. Geological Survey, say ten years ago, and let it be supposed that this map at the time it was made, was absolutely perfect. The map is supposed to show the contours, woods, streams, houses, and other features that are usually represented on such a map. In the ten years since the map was made, it is reasonably certain that some changes have been made by the works of man. It is improbable that natural features would have changed, such as streams, woods and hills, during

(Continued on page 391)

Recent Developments in Marine Lighting—II*

The Unattended Light

[CONTINUED FROM SCIENTIFIC AMERICAN SUPPLEMENT FOR JUNE 7, 1919, NO. 2266, PAGE 368.]

DURING recent years the greater attention paid to the provision of warning and leading lights has led to lights, including buoys, beacons, and lightships. Such lights have been combined with certain auxiliary aids to navigation, including automatic fog guns.

Until a comparatively recent date, the principal coast lighting authorities, as well as the harbor trusts which are responsible for the lighting of the approach channels to docks and harbors, suffered from the lack of regulations governing lighting by buoys and beacons. It was not, indeed, until the year 1882, at a conference of the general lighthouse authorities of the United Kingdom, that a uniform system was adopted for buoys and beacons. At that conference questions of color, visibility, shape and size received consideration, and as a result buoys were divided into various classes, the character of the light being made to depend on whether the spot to be marked was in a sheltered harbor or in the open sea or other exposed position, as well as upon the depth of water and other distinguishing features. It was decided that the buoys should be constructed of steel, and be fitted with bulkheads to lessen the danger of their sinking from accident.

A point to be borne in mind in connection with permanent unattended lights is that the light is most needed when the atmosphere is least clear, so that a light that will only give the range required under the best atmospheric conditions cannot be selected for this work. Unattended lights are employed, of course, for showing the line of a channel or the entrance to a harbor, and, where convenient, beacons are employed in place of buoys, the method of lighting being the same in both cases. Various systems of lighting are in use; the buoys and beacons are fitted for burning oil, coal gas, compressed oil gas or acetylene in the dissolved or generated form, while a recent innovation, of which more is likely to be heard, is the unattended electrically lighted buoy. In the case of acetylene the gas is frequently in the dissolved form, stored in cylinders, and is a most convenient illuminant to employ, since the gas is supplied clean and the period of time during which the gas will burn can be calculated with great accuracy.

The length of time during which any permanent light will burn without attention depends essentially on the size of the containers and the amount of gas consumed per hour. With oil gas the period is usually from one to three months, while with acetylene it may vary from one month or less up to six months, or even a year or more. In practice lights are very seldom left longer than six months without examination, because, for one reason, the lenses gradually become dimmed by the deposit of dust and the salt from the sea spray. Where the lights are fairly accessible they should not be left for a longer period than three months without attention, and wherever possible arrangements should be made for inspection each month.

ILLUMINANTS.

As a matter of historical interest, it may be pointed out that it was in 1878 that gas buoys with fixed occulting lights were first adopted by the Trinity House authorities, these lights being at 10 candle-power. A special design was developed at a later date—in 1896—by Mr., afterwards Sir Thomas, Matthews. This new buoy was constructed to hold 380 cubic feet of gas and to show an occulting light of 50 candle-power for 2,500 hours, the light itself being 10 ft. above the level of the sea. It was not until 1910 that the first acetylene gas lights were established in the Trinity House service. Improvement in the design of unattended lights has, however, proceeded with very rapid strides, and gas buoys showing a light of 890 candle-power at a height of 20 ft. above sea level have been quite recently adopted. The great majority of the lighted buoys in this country have now been converted to the incandescent system of illumination, and are fitted with mechanism controlling the period of activity according to the duration of daylight. Many of the unattended buoys carrying lights are also fitted with fog-signalling apparatus.

Although in modern practice acetylene is largely employed as an illuminant, various other systems have been, and are being, employed. It is now nearly forty years since compressed oil gas, originally introduced for railway carriage lighting, was applied to marine work. In the original system, which was German, but which is now owned by an English company, the gas is stored under high pressure within the buoy and is reduced to burning pressure by a special governor in the lantern. It was at one time hoped that it might be possible to use coal gas for the lighting of buoys and beacons, but the fact that under compression it loses its illuminating power ruled it out for the purposes of marine lighting. The first gas buoy used in England was supplied in 1878 to the Trinity House authorities, and was moored in the Thames Estuary off Sheerness. In the year 1881 a beacon lighted by compressed oil gas was erected on the Clyde. In the following year tests were made with automatic lighting on the Lindberg system, and this method was further improved in the Benson-Lee lamp which burned paraffin. Permanent wick lamps were introduced in France in 1891, and Wigham lights have since been adopted in many places, the feature of these being that a fresh portion of wick is constantly exposed to the flame.

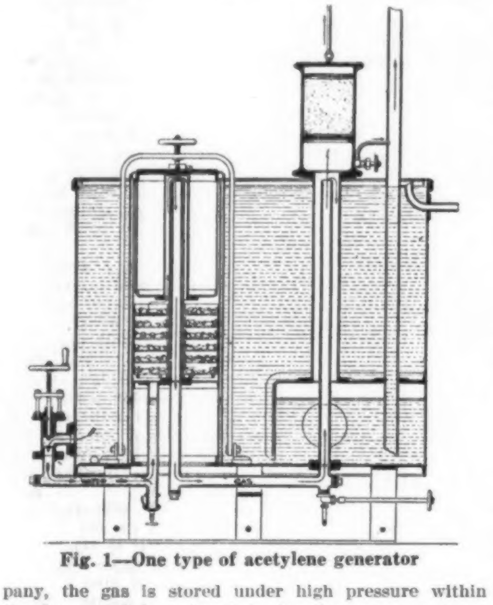


Fig. 1—One type of acetylene generator

The use of acetylene is, however, gradually increasing. It is recognized that the acetylene flame, owing to its brilliance and intensity, is much superior to that obtained with oil gas, and although its use in unattended lights has been accompanied by considerable difficulty—some of the earlier types were too complicated to be entirely satisfactory in service—the principal troubles have now been overcome. In the case of automatic generators the carbide-to-water type has, except for buoys, been adopted on a considerable scale, particularly in Scottish practice. Fig. 1 illustrates an acetylene generator on the Chance system, from which, it is claimed, all moving parts liable to derangement have been eliminated. The apparatus consists of a mild steel water-tight chamber in which is fixed one or more generating vessels, the covers of which are formed of loose cylinders. The space between the outside of the generators and the inside of the chamber is filled with water to form a seal round the bottom edge of the loose cover. There are six easily removable trays for the carbide in each generating vessel, and an important feature is that the trays are carried on a holder. The generator is fitted with all the necessary drain and draw-off cocks. A chamber charged with a special purifying material is fitted on top of the generator.

In another type of automatic generator, of which considerable numbers are in operation, the carbide is placed in a central tube and as no valve is provided, charging has to take place before the apparatus is filled with water.

In the Collier generator the removable carbide container principle is adopted. When the carbide charge is exhausted the container can be removed and a spare charged container inserted without difficulty, even though the fixed tube be full of water. The containers are fitted with valves. The principle of operation is similar to that of the water-to-carbide type, but the water in the generator is contained in a tank which surrounds the central tube, generation being interrupted when excess gas is formed by the pressure of the gas itself forcing the water away from the carbide. Another Collier buoy, what is called the grounding buoy, is intended for use in tidal rivers. In this case there is a special arrangement whereby, when the buoy is left stranded, sufficient water is trapped within it to enable the generation of gas to continue until the tide again rises.

Recent practice tends in the direction of a greater use of acetylene in the dissolved form. All the manufacturers engaged in the business now supply buoys designed for the use of dissolved acetylene. The buoy illustrated in Fig. 3 is, it will be noted, of a combination type, so that either dissolved acetylene or automatic generation can be employed.

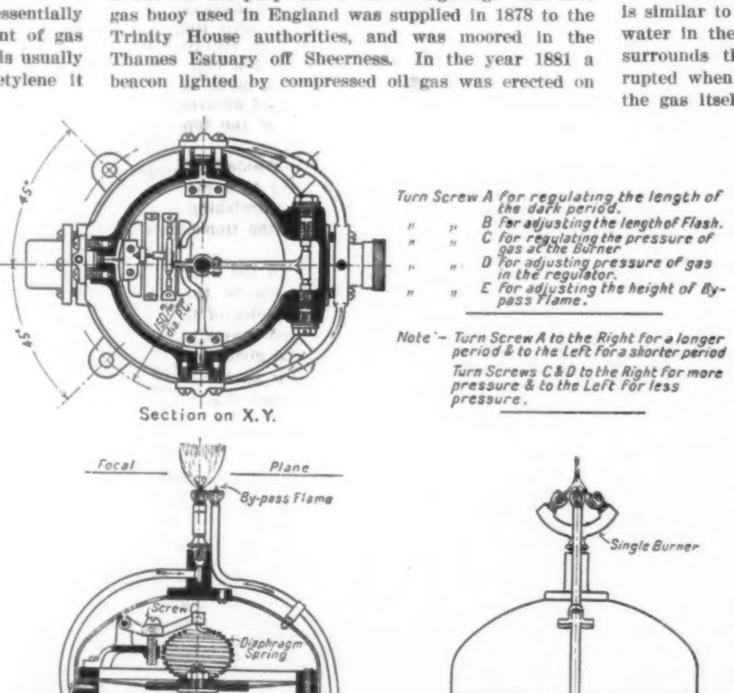


Fig. 2—A flasher for the unattended light

TYPES OF FLASHERS.

As all buoys are either fitted with an occulting or flashing apparatus, special devices have been designed to give the light the necessary characteristic. The general principle adopted is the same in all cases. A pressure regulator is installed between the storage cylinder and the flasher, and delivers the gas at the constant pressure required. To this is added a device for cutting off the supply of gas at predetermined intervals to impart varied characteristics to the light automatically. In the Patent Lighting Company's system the gas when passing to the burner raises a diaphragm and closes the gas inlet. As the gas is consumed by the burner the diaphragm descends and opens the inlet valve. In a later device a variation has been introduced with a view to

*From *The Engineer*.

maintaining the intensity of the light during the whole of the flashing period; this particular type of flashing apparatus is operated by means of a gas motor. It should be noted that there is a considerable difference of opinion as to the light characteristic, some authorities favoring a flash of not less than one second in duration and others showing a preference for a flash lasting one-tenth second.

The Chance flasher, illustrated in Fig. 2, consists of two chambers, each of which has a leather diaphragm for operating by means of the gas pressure the mechanism for giving the required duration of light-to-dark period. By means of a simple outside adjustment of two screws the length of the flash can be altered from .02 of a second to 4 seconds, and the dark interval made any desired length from 2 to 20 seconds or even longer. By a further adjustment the apparatus can be made to give a continuous light. The function of the lower chamber shown in the engraving is to reduce the high pressure of the gas in the supply cylinder down to a pressure suitable for burning without flaring. A spring on the top of the diaphragm allows the reduced pressure to be adjusted. The gas passes from the lower chamber through a pipe into the upper chamber, which is the flasher proper, and which contains a special trip mechanism giving the required characteristic. The operation is, of course, quite automatic. The by-pass flame is kept burning continuously so as to light up the main burner when gas is admitted.

The Aga flasher is illustrated in Fig. 4. The gas, having been reduced to the necessary pressure, passes into the flasher chamber through a valve, which remains open during the whole of the dark interval. When the predetermined quantity of gas has been admitted to the flasher the inlet valve is closed and the outlet valve to the main burner automatically thrown open, permitting the passage of the accumulated gas to the main burner where it is ignited by the pilot flame. When the total quantity of gas admitted has been consumed the outlet to the burner is closed and the inlet valve again opened. The inlet valve regulates the rate at which gas is admitted into the flasher. Only a small volume of gas is dealt with at one time, a fact which is one of the main distinguishing features between acetylene and oil gas systems. The length of the light period is dependent upon the capacity of the flasher and upon the size of the burner. The length of the dark period depends upon the velocity of the gas flow into the burner. The Aga flasher may be made to produce various light characteristics ranging from single flashes to double or group flashing. The system generally is based on the theory that a short flash of high intrinsic brightness is superior as a marine signal to longer flashes separated by longer dark intervals.

A distinctive feature of the Aga system is the use of a sun valve for automatically extinguishing the light in the morning and setting the apparatus in action again at night. It is claimed that this device is preferable to the more commonly employed clockwork or electrical devices, and that the sun valve, now in use in many parts of the world, including the Panama Canal, is capable of effecting economies in gas consumption ranging up to 40 per cent. The valve is of quite simple construction, and consists essentially of a glass cylinder containing four metal rods. The central rod is coated with lampblack, which enables it to absorb light while the three others are polished. On exposure to light the central rod, owing to its power of heat absorption, expands more rapidly than do the polished rods, and its expansion is utilised to close the inlet gas valve.

The device used by the Patent Lighting Company for automatically lowering and raising lights at sunrise and sunset is in the form of a clock, and can be used for all attended lights. The clock is provided with a dial graduated for 24 hours and supplied with holes at every quarter of an hour into which small metal pins can be fitted; the position of these pins determines the period of light and darkness. The pins actuate the gas valves as the dial revolves.

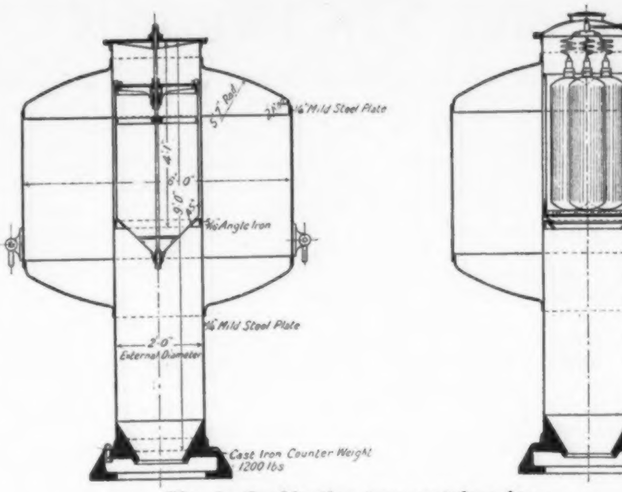


Fig. 3—Combination type acetylene buoy

Another type of flashing apparatus is illustrated in Fig. 5. It is claimed that the working parts of this flasher are easier of access than in other designs, for they are fitted over a leather diaphragm which need not be removed to allow of the adjustment of the parts. The details of the flasher, it may be noted, are

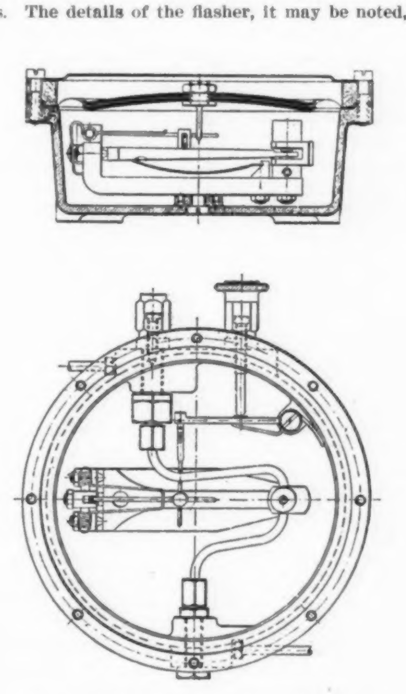


Fig. 4—Another style of gas flasher

of especially strong construction and are, therefore, unlikely to be affected by a severe shock of the kind frequently experienced in marine service. The period of flash and eclipse can be altered from the outside by means of the adjusting spindles, and the length of flash can be made to vary from .25 of a second up to 10 or more seconds.

Fig. 5—A flasher of great accessibility

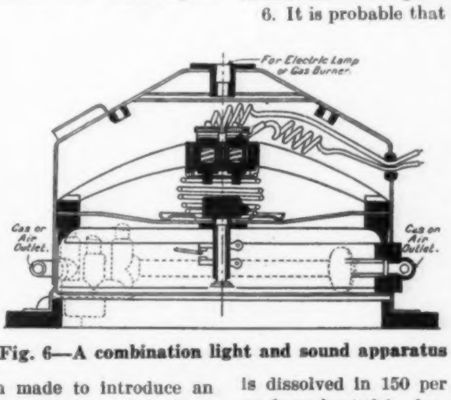


Fig. 6—A combination light and sound apparatus

Attempts have recently been made to introduce an automatic electric light combined with a sound signal for buoys. One of these is the invention of Mr. A. P. Collier, and is illustrated in Fig. 6. Incandescent electric lighting from a local source of supply has been occasionally used, and in one case, at Irvine Pier in Scotland, a number of Leclanché cells supply current for the purpose.

Tests on Strength of Joiner's Glue

An account of experiments carried out in 1894, but not published till 1918, states that the older methods of testing glue depended chiefly on chemical analysis. The idea that the strength of a glue is proportionate to the chondrine and gluten contained is erroneous, as these substances become partly decomposed if the glue is manufactured under a high temperature, and lose much of their binding strength without any change taking place in the chemical composition.

A series of preliminary experiments give a general description of color, percentage of water, and of ash left when heated in a crucible. Further tests were made on the effect of immersing glue in water at 57.2° and 59° F., and on the quantity absorbed at this latter temperature during 45 hours. The amount of insoluble material contained in the glue was determined by heating it in a soaked condition without bringing it to boiling point.

Tests were made on blocks of beech wood, 185 by 126 by 50 mm. thick with glued jointing surfaces, 50 by 50 mm., equal to 3,875 square inches. The glue applied was dissolved in proportions of water varying from 400 per cent. to 50 per cent., and the blocks were heated to temperatures ranging from 68 to 140° dried under pressure for 24 hours, and the tensile strength ascertained in an ordinary testing machine for this purpose. A maximum tensile strength of 984 lbs. per square inch was obtained with glue containing 150 per cent. of water, applied to wood heated to 104° and dried under a pressure of 284 lbs. per square inch for 24 hours, 400 per cent. of water reduced the strength of the point to 48 lbs. per square inch, and a reduction to 50 per cent. resulted in a diminution of strength. Heating above 104° was also detrimental.

It was found that the binding strength of glue is related to the viscosity, and may be expressed as a ratio between the time required by unit volume of glue dissolved in water to flow through a narrow tube and the time required by a similar quantity of pure water.

The results are summarized as follows:

1. The reduction in the tensile strength of surfaces jointed with glue diluted with equal portions of water was proportionate to the temperature to which the test pieces had been heated before they were glued together. When the dilution of the glue reached 300 per cent. the pre-heating became beneficial.

2. The tensile strength of glued joints was found to be inversely proportional—but not uniformly so—to the dilution of the glue. A considerable decrease in strength takes place with a dilution between 150 per cent. and 200 per cent., while it is less marked between 200 and 300 per cent.

3. The pressure under which a glue joint was dried did not have any marked influence on the strength if the glue was diluted with 100 to 150 per cent. of water only, but with higher dilutions the strength of the joint was increased considerably if test pieces were pre-heated and dried under high pressure.

4. Commercial glues of superior qualities produced stronger joints.

5. Glues diluted with 100 to 150% of water gave uniform results that agreed with their strength and quality.

6. It is probable that the quality of any glue may be obtained by comparing the viscosity with that of a standard solution having 556% of water at a temperature of 95°, but further careful experiments are needed.

7. The deductions 1—5 apply to the whole series of experiments, and lead to the following conclusion3:

(*a*) The methods adopted appear suitable for ascertaining the binding strength of different kinds of glue.

(*b*) The most reliable test is obtained when the glue is dissolved in 150 per cent. of water and applied to surfaces heated in dry air to a temperature of 104° F.

(*c*) The pressure under which glued joints are dried does not appear to have any regular effect on the strength, if it is not less than 12 lbs. per sq. in.

(*d*) Data for establishing definite claims regarding the binding strength of glue must be left to further experiments.—*Mitteilungen aus dem Königlichen Material-prüfungsamt.*

Meeting New Demands*

What the War and the Airplane Development Mean to the Paint and Varnish Makers

By A. de Waele

The war has been responsible for many changes in several industries, but in the case of the paint and varnish industry in particular it has produced results which should favorably influence future development. This industry is essentially one in which the inner knowledge of the mechanism of manufacture has not been furthered to a great extent by the help which pure chemistry has lent to its service. It has, however, attained a very considerable degree of perfection by the methods of empiricism. In spite of the practice of the more up-to-date firms to introduce scientific control into the factory, comparatively little progress has resulted which might be directly attributable to the influence of pure scientific research. One need not elaborate on the highly involved chemistry and physics of paint and varnish manufacture to seek a reason for this. The industry is particularly one which calls for a close collaboration between the academic chemist and his works' confrère. The furtherance of our knowledge of many problems relative to an industry which is at once utilitarian and decorative is hindered, however, by the difficulty of bringing together the work of the two schools. The "secrecy" of the industry, and the fact that the financial importance of the majority of the paint and varnish firms does not warrant the establishment of a "research department," such as we know it in many other more purely chemical industries, are mainly responsible for this condition of affairs. Our knowledge of the chemistry of the reactions occurring during the oxidation and "boiling" of drying oils is lamentably small, more attention having been devoted to the constitution of the glycerides in their raw state. In spite of this, however, the technology of the treatment of drying oils has attained a high degree of perfection, and were it possible to place at the disposal of the pure organic chemist such information without jeopardizing the trade value of the processes involved, there is little doubt but that a more scientific conception of such reactions would speedily result.

As has been pointed out, the paint and varnish chemist has progressed in his work by an uncanny combination of science and empiricism. An instance of this is to be found in the ready manner in which the exacting demands of the aeroplane industry have been met in so far as paint and varnish products are concerned. With the introduction of the aeroplane as a new weapon in warfare, a problem presented itself which involved several new considerations of the resisting properties of protective surfaces. In the aeroplane we have a structure which moves quickly from a warm to a cold atmosphere, and the rapidity of transition is such that one cannot but assume that at the first entry into the freezing air, the temperature of the body supporting the protective covering must be many degrees higher than that of the protective surface itself. We have thus a case of an extreme mechanical strain on the very thin film of protecting paint or varnish. The importance of the non-failure of such protective coating on such an important part as, for instance, the airscrew cannot be exaggerated. In addition, the centrifugal force acting on the airscrew revolving at high speeds is such that an absolute state of perfection is required in the material of its construction. An important factor in the latter is the efficient protection of the sealing of the laminations of the airscrew against moisture, etc., and in view of the considerable bending which the propeller undergoes during its rotation, the question of elasticity of the protective film is of paramount importance. The liability of the airscrew to splashing with hot lubricating oil and petrol is also to be noted. In addition to this *resumé* of the necessary properties which protective coatings for airscrews should possess there comes the economic question of speed of output in so far as application is concerned. This brings forward the old-time tenet of the varnish and paint maker to the effect that the antithesis of reliability and durability is rapidity in drying after application.

The authority responsible for the examination of aircraft products used in the war early grasped the nature of the problem which resulted from a demand for high efficiency, and wisely decided to leave the fulfilling of the necessary requirements to the discretion of the manufacturers by specifying the conditions obtaining in use, and, as far as was practicable, refraining from specifying the composition of the products to be manufactured. As a result now of expert inspection by Government technologists, varnishes and paints for aircraft are regularly supplied which efficiently fulfil the exacting requirements referred to above, while permitting of a rapidity of output in so far as speed of application is concerned, hitherto considered impossible.

The production of varnishes for the protection of the "dope" on wings has also proved a new and very difficult proposition, necessitating an entire revision of the preconceived ideas on oil varnish, the details of which cannot be discussed in this article. Another interesting problem which has been successfully solved is the production of an acetone-resisting paint for use on parts which come in contact with this solvent on application of the dope. The interest in this product lies in the fact that acetone has been the constituent of most commercial "paint removers."

The question of the shortage of many raw materials is one which has arisen during the present war, but with the exception of the staple raw material, linseed oil, modern paint technologists had for some time past placed on a secure foundation their knowledge of the properties and uses of many substitutes for what were previously considered indispensable ingredients. Among these may be mentioned white lead and turpentine.

The absolute stoppage of supplies of the basic raw material of the paint maker, to wit, linseed oil, for other than purely Governmental work was, however, a serious question to the manufacturers. As an alternative to linseed oil, the paint manufacturers were offered linseed oil fatty acids. Since the characteristic drying of linseed oil to a hard elastic film is intimately dependent on the triglyceridic structure of the oil, and early consideration on the paint chemists' part showed the inexpediency of relying on the commercial possibility of synthesising the fatty acids to polybasic esters, it became apparent that an absolute stoppage of the industry was threatened if the problem were not attacked on unorthodox lines. The paint manufacturers therefore formed a Federation, which decided to pool the scientific resources of its members for the solution of the problem of the adaptation of linseed oil fatty acids to paint manufacture. As an outcome of the research undertaken, many hundreds of tons of quite excellent paint have been manufactured from the fatty acids.

To turn now to a more general review of the industry, it may be noted that of late years a distinct change has been taking place in the nature of the products manufactured by the paint firms. I here refer to ordinary paint, a product which is very simply defined as heavily pigmented linseed oil. From time immemorial such a product had been generally accepted as the standard of a pigmented protective surface, in spite of its general inferiority of properties. The selection of pigments, with a view to employing the optimum of durability, had in recent years occupied the attentions of many of the technological associations. Looking at the results obtained, however, we are struck by the absence of definitiveness of the conclusions arrived at. The fact of the matter is that there is little to be done in attempting by means of the added pigment to modify advantageously the weather resistance of the medium used—raw or boiled linseed oil. One only has to call to mind what one might call the purely accidental composition of linseed oil as a mixture of glycerides of saturated and unsaturated fatty acids and the variety and amount of its soluble and volatile oxidation products to find a reason for this. After all, the oil only serves its purpose as a protective agent during a short intermediate period of its history after application, characterized by that comparatively short period when its increase in weight by oxidations is at or near a maximum. Even at this point it possesses the disadvantages of considerable porosity to air and water and giving off volatile products of an acid nature often reactive with the pigment used in a paint. That indefinite preparation—"boiled" linseed oil is little better. A certain degree of stabilisation of the molecules of unsaturated glycerides has undoubtedly been obtained by slight ring forming polymerisation obtained during the boiling process, but a considerable impetus to further destructive oxidation has been given by oxygen absorption at an elevated temperature, with the result that disintegration of the protective film occurs if anything earlier than in the case of raw oil.

The improvement and change referred to is in the manufacture of enamels in the place of paints. Enamels are characterized and basically to be distinguished from paints in the greater stability of the medium used, a highly polymerised "stand oil" or lithographic varnish with or without the addition of an elastic weather-resisting varnish being employed. Other characteristics of enamels are the greater degree of fineness. From this there results a high gloss and a very permanent suspension of the pigment during storage, the latter being due to the formation of oil-soluble zinc soap and the presence of zinc oxide mainly in the suspensoid state, a fact which is clearly shown by the tendency of an ether-diluted zinc oxide enamel to pass through a fine filter paper. It being generally recognized that a surface of porcelain-like gloss is one of the important factors in maintaining effective weather resistance of the dried film, it was found that this was only obtainable by causing the degree of pigmentation of the product to be in the nature of half that usually obtaining in oil paints. This, and the relatively lower opacity of zinc oxide as compared to white lead, results in considerably less body or opacity being obtained in enamels. This shortcoming, however, is rectified by the employment of undercoating of high opacity but lower degree of elasticity, impermeability, and resistance to weather than the final coat. The two latter factors do not adversely affect the general structural excellence of the whole coating, while the former has been shown in practice to be an actual advantage.

A class of preparation which, as the basis of protective coatings, bids fair to become a serious competitor of oil products, is the so-called flexible pyroxylin. This has for many years past been used as a substitute for the oil basis in artificial leather cloth under a registered trade name. A solution of cellulose nitrate in solvents of comparatively high boiling-point was mixed with a substance conferring flexibility such as castor oil, nitrated castor oil, etc., the proportion of the latter being such that flexibility and chemical stabilisation were given to the unstable and inelastic film of cellulose nitrate without any of the properties of castor oil as a liquid becoming apparent. The stability of castor oil to atmospheric oxidation and its apparent inhibiting effect on the spontaneous decomposition of cellulose nitrate, rendered it particularly adaptable as the agent for securing that degree of elasticity which would allow of the film obtained comparing with an oil varnish film. Owing, however, to the necessarily low content of total solids in the solution which would allow of a working viscosity being obtained, the film yielded on evaporation is so thin that for most decorative purposes the product would not replace oil varnishes satisfactorily. Moreover, much development is needed before the cost of the raw materials used would allow of serious commercial competition with oil varnishes.

It is probable that the future developments of the paint and varnish industry will lie firstly in the direction of internal improvements in manufacture and economisation of time in the present-day lengthy processes. An appreciation of the fact that linseed oil is by no means the ideal oil to employ when accurately controlled processes are involved and more perfect and exact results are required, will lead to a more extensive investigation of the properties of oils of "simple" glyceridic structure, such as China wood oil. The recent discovery of "Oiticica" oil (Bolton and Revis, *Jour. So. Chem. Ind.*, 1918, 430A) shows promise of the possibility of utilising an oil possessing the "pure glyceridic" properties of China wood oil to an even greater degree.

*From *Jour. Soc. Chem. Ind.* (London).

Fixation of Atmospheric Nitrogen in Japan

The manufacture of nitrates by the fixation of atmospheric nitrogen is rapidly becoming a world industry. In this the Japanese are keeping in line with American and European enterprise. D. Takamine has, it is said, purchased, on behalf of Japan, the American modification of the Haber process. It is intended to instal a plant to use this process for the production of synthetic ammonia. The Japanese Government has provided means for the building and maintenance, in a suburb of Tokio, of an experimental laboratory for research concerning the conditions of the fixation of nitrogen. This laboratory is to be ready for work before the end of 1919.—*Zeitschrift für angewandte Chemie.*

Burning Fine Anthracite and Bituminous Coal

Fuel conditions during the last two years have been such that the users of coal for power generation have been glad to obtain any grade possible in order to keep their plants in operation. In many instances the practice of mixing what is known as anthracite screenings and bituminous coal has been employed by operators of hand-fired furnaces equipped with natural draft.

Those who have never burned such a mixture might imagine that the difficulties in burning anthracite screenings with a natural draft would be such as to prohibit their use. Experience, however, has shown that they give satisfactory results when properly mixed with bituminous coal. Anthracite coals below buckwheat sizes are valuable for fuel as they contain almost as much carbon as the larger sizes and but little more ash and sulphur. They are, however, difficult to burn with natural draft and should, therefore, be mixed with some soft coal.

When burning a mixture of fine anthracite and bituminous coal, the percentage of screenings will vary, depending upon the grate and the draft. Six or seven parts of anthracite dust to one of bituminous coal makes a fuel that burns well. Increasing the proportion of soft coal makes a quick fire, but produces more smoke. Excellent results can be obtained with 25 to 30 per cent. of small-sized anthracite and 70 to 75 per cent. of soft coal. The mixture will give a hot fire, but will produce some smoke. A mixture of half-and-half fine anthracite and bituminous coal can be successfully burned in a furnace having a good draft.

It is important to thoroughly mix the coal before firing. This is best done by bringing it into the boiler room in a wheelbarrow or by other means, dumping first one load of one kind and then one of the other kind in a pile on the floor and turning the pile over several times somewhat as concrete is mixed. If the mixing is done properly, the firing method need not be changed from that employed in burning soft coal.

Regardless of what mixture is burned, all cracks in the boiler settings should be stopped to prevent air from leaking into the furnace. If a damper regulator is installed, it should be allowed to operate the damper in the smoke connection to the chimney for the control of the steam pressure. Some firemen have the habit of opening the furnace doors to admit cold air over the fire to prevent the boiler from making steam too fast and at the same time allow the damper and ashpit door to remain wide open. The furnace doors should never be left open for any such purpose. If the damper is not in working order, it should be put in shape so that the draft can be controlled by it rather than by means of the ashpit doors. Frequently, the damper regulator is out of order. If this is the case, it should be repaired and connected with the damper so that it will automatically regulate the draft and steam pressure. Arrangements should also be made so that the damper cannot close tight and thus shut off the draft altogether.

As regards the furnace, the grate bars should contain up to ½-in. air space, which is suitable for burning fine anthracite and soft coal. As the anthracite bakes with the soft coal and forms into coarse particles, it will not fall through the grate. To obtain the best results keep the fuel bed level and not too thick; between 5 and 10 in. is considered good practice. It is well to watch for holes in the fire and keep them filled, otherwise an excessive volume of air will pass into the furnace.

In handling a fire the fireman should not disturb the fuel bed too often, as this mixes the ashes with the fuel and causes clinkering. If shaking grates are used, the ashes can be freed from the fire by frequent shaking down, but it is advisable to stop shaking as soon as live coals begin to fall through the grate. After firing, the fuel bed should be left alone and the fire tools should be used as little as possible.

It may be necessary to employ a slice bar if stationary grates are used; and if so, it should be run in under the fire along the grate. Moving the bar back and forth a few times will sift some of the ashes through the grate. If the soft coal is of the coking kind, it may be necessary to slice the fire occasionally so as to break the crust, but care should be taken not to mix the ashes with the burning fuel.

As clinkers and some ash will not pass through the grate, the fires must be cleaned at intervals. The periods will be governed by the proportion of ash in the coal and its character, also by the kind of grate used. A stationary grate will require more frequent cleaning than one of the shaking type. When cleaning a fire, carefully remove all clinkers and ash.

Various methods are used in cleaning fires. One that gives satisfactory results is as follows: Burn down one side of the furnace as much as possible and still keep up the steam pressure during the cleaning period; then wing the live coals to the active side of the grate and with a hoe pull the refuse out of the furnace and into a wheelbarrow. Having cleaned one side, evenly spread some of the live coals from the uncleaned side of the furnace on the clean grate and cover lightly with fresh fuel. When the clean side of the furnace has been built up, the dirty side is burnt down and cleaned in the same manner.

In case a light fire is being carried, it will be necessary to build up one side of the furnace to have enough live coals to cover the grate on the side that has been cleaned. With a boiler that is not being pushed hard, it is possible to burn practically all fuel to ash on the side that is to be cleaned.

Another method of cleaning fires with dumping grate is as follows: The fire on the side to be cleaned is burnt down and the live coals are brought forward on the front portion of the grate; the rear section is then dumped and the live coals are pushed back on the clean part of the grate; the front portion is next dumped and the live coals are evenly spread and then covered with fresh fuel. After building up the clean side, the other side of the grate is cleaned in like manner. Experience will determine the proper cleaning period for each individual plant.

If the grates are of the shaking type and are properly handled, there will be less trouble from clinkering as the ashes can be shaken into the ashpit. Clinkers are nothing more nor less than melted ash, and their formation can be controlled to a large extent by the manner in which the fireman handles his fires. The more excessive the heat in the furnace the greater the probability that clinkers will form. Furnaces that are run at a low rate, and therefore at a comparatively low temperature, are troubled but little with the formation of clinkers.

As has already been said, stirring the fire and mixing the ashes with the live coals produces clinkers because the ashes, being exposed to the intense heat of the burning coal, are fused into a large mass. Naturally, the grade and mixture of the coal will have much to do with the nature and formation of the clinker. Carrying very thick fires coupled with the stirring of the burning fuel bed is a sure way to produce clinkers.

One may ask why a thick fire will cause clinkers to form. This is because a thick fuel bed offers resistance to the passage of the air through it. Without the free passage of air through the fuel bed, the ashes become heated, and upon reaching the melting point, they fuse together and become a solid mass upon cooling. Therefore, clinkers will be greatly reduced if thin, level fires are carried.

In burning a mixture of anthracite and bituminous coal, it is generally not economy to burn anthracite containing more than 20 per cent. of bone and non-combustibles. Furthermore, in many plants the expense of disposing of the ashes would offset the gain made in burning the mixture. One plant may find that a certain mixture is cheaper than another; the second may find that still another mixture is less economical. Each engineer who plans to burn mixed coal should try various mixtures and then stick to the one that gives the best results with his particular equipment.—*Power.*

Helium for Airships

One of the greatest achievements due to the pressure of war conditions, from the technical point of view, is the production of helium in quantities sufficient for airships. A rare gas discovered by Ramsay about twenty years ago, not more than 100 cubic feet had been obtained up to two years ago. Someone in the British Admiralty had imagination enough to propose the separation, on a large scale, of helium from natural gases in Canada, which gases contain about one-third of 1 per cent, of helium, and experiments were undertaken at the University of Toronto. The U. S. Bureau of Mines took the question in hand, and with such success that on the cessation of hostilities in Europe, there was, compressed and on the dock ready for floating, 147,000 cubic feet of nearly pure helium, and plants were under construction to produce at least 50,000 cubic feet a day at an estimated cost of not more than ten cents a cubic foot. The gas, which is non-inflammable, has about 92 per cent. of the lifting-power of hydrogen.—*Engineering and Mining Journal.*

New Uses for Zircon

The growing demand for zircon for electric furnaces has directed attention to that mineral. It is the most refractory of known substances, and as such is the most suitable for furnace linings. To reduce the cost of zircon fire-brick, several patents have recently been taken to use that substance as a coating to bauxite brick. In a Siemens-Martin furnace, the use of such bricks has, it is said, reduced the cost of maintenance 50 per cent. Doubtless the use of zircon-brick would reduce the cost of any type of furnace. In Germany it is believed that there is an important future for zircon, and this belief is finding expression in efforts to obtan concessions and contracts in Brazil, which country is known to be rich in zircon ore deposits. The remarkable progress recently made with the electric-furnace has put the question of a good refractory material in the foreground; but other uses of zircon are coming in sight. In the earthenware and glass industries it will probably meet a want. Here is a promising field for research. Far-seeing manufacturers will experiment on their own account when they have become better acquainted with the peculiar properties of zircon. —*Metall und Erz.*

A Novel Pile Driver

So much railway construction requires piling foundations that no surprise will be occasioned by announcing the addition of a special and novel pile driver to railroad equipments. Our front-page illustration figures such a machine developed and built at Cleveland, Ohio. As is apparent on inspection the new device combines locomotive crane with an attachment which when raised into position constitutes a pile driver ready for work. It is claimed that the best feature of this piece of equipment consists in the freedom from necessity to "pack up" anything when the pile-driving job is over. By manipulating a special lever the pile driver is folded down into compact form and in a position where it is out of the way of overhead obstructions on railway lines during transportation to a new location.

Surveying and Mapping from Airplanes

(*Continued from page 387*)

such a short period. We may assume that new roads have been made, old buildings torn down, or have burned, and new ones erected, wooded areas have been cleared, and brush or young trees may now be on areas that were bare at the time that the original survey was made. In order to test such a map and learn whether it was up to date, it would be necessary by the usual methods, to send a surveyor into the field to go over the area in great detail. Of course an inspection could be made of an area by driving over it, but many changes might be overlooked by this method of inspection.

How much simpler and more reliable it would be to send an aeroplane over the area in question and make a series of photographs. These photographs would show at a glance, the exact areas where changes in the features had occurred, and if the changes were not too complicated it is probable that we would be able to place the new features on the map directly from the photographs. The process would be to fit in the new features between unchanged old features, which of course would also be shown on the photographs.

PHOTOGRAPHIC PLATE SHOULD BE HORIZONTAL.

In what has been said above, it has been assumed that the photographs have been made with the camera vertical, or, in other words, with the photographic film or plate in a horizontal position. It is only in this way that absolutely accurate photographs could be made. If the camera is tilted from the vertical at the instant the exposure is made, then there will be a distortion of the photograph so far as the map is concerned. If this tilting were known, then the photograph could be rectified and the features shown on the map with the same accuracy as if the plate had been horizontal at the time of the exposure.

It is hoped that methods will be developed for holding the camera in a vertical position at the time of exposure. I know of none now in use which is entirely satisfactory.

CONCLUSION.

I may conclude that aeroplane surveying can be done now and it undoubtedly has a bright future. Much experimentation must be done, however, before the aeroplane can be used exclusively in high grade work.

I feel that the aeroplane can now furnish maps of a low order of accuracy so far as scale and position of features are concerned, which will be of considerable value in many branches of industry and commerce. They will undoubtedly be extensively used in unmapped areas in this and other countries in the very near future, in these reconnoissance surveys and maps. But I hope they may be of great use in more accurate work.

I can pledge the Coast and Geodetic Survey, so far as its limited resources will allow, to take its part in making such tests by aeroplane that may be feasible in connection with surveying and mapping.

The Chemistry of Laundering

The Cleansing of Cloth as an Example of Science in Service of Man

By Prof. I. Newton Kugelmass, Howard College

A RETROSPECT of the laundering industry reveals remarkable advances, under ever changing social and economic conditions. Today the magnitude of this industry warrants scientific analysis. The sanitary and economic function of the laundry is indispensible, but its efficiency must be increased many fold before it will be giving the service which it owes society. Living in a scientific age, we have the right to demand of the launderer not only a grade of work excellent in appearance with maximum conservation of the fabric, but as well a reduction in the cost of operation. To meet these obligations to society the launderer must be a student of his business; he must substitute knowledge for ignorance, system for chaos, scientific accuracy for empiricism, quantitative rational methods for the rule of thumb. Only thus can we have maximum efficiency at minimum cost to both launderer and customer.

It is high time for every launderer to realize the dawn of a brighter day for his industry and to apply available knowledge to the laundering process. This can only come about through understanding of the fundamental principles of physics and chemistry. Both these sciences are essential for successful laundering in the scientific sense of the expression, since that depends upon proper control of the physical and chemical reactions involved. Thanks to the United States Bureau of Standards and the Mellon Institute for Industrial Research (the latter in connection with the fellowship on laundering under the auspices of the National Laundryowners Association) much has been accomplished in the way of setting up the background of knowledge, and much more in the dissemination of the results of research.

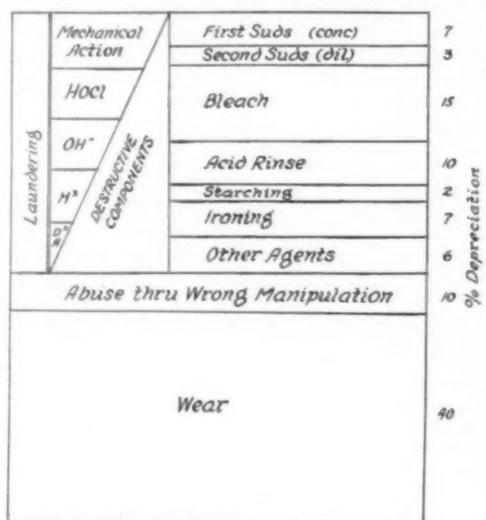
A preliminary survey is of interest as indicating the scientific factors that are interrelated with the laundry problem. On the chemical side we have to consider the chemical nature, structure and properties of fibers; the constitution and properties of dyestuffs; the chemical nature of the substances to be removed; the composition of laundering reagents and the standardization of their commercial nomenclature; the properties of these reagents and the standardized specifications for compounding them, in terms of available utilizable components; the exact methods for the preparation of reagents for ready use; the cleansing power of detergents; the effects of detergents, of the hydrogen ion and the hydroxyl ion, of laundering reagents and their adulterants, of heat, friction and other features of the laundering processes upon the tensile strength and upon the texture of raiment, as determining, respectively, the wearing qualities and the appearance; standard formulae for procedures; proper conditions of temperature, pressure, concentration, saturation, time, etc., for the various operations.

Among the physical factors must be considered the classification of soiled fabrics as to color, texture, nature and extent of soil; economic utilization and control of generated and exhaust steam; standardization of piping to the washing machines; adaptable appliances for the preliminary preparation of reagents for ready use; automatic machinery and adjustments for operations; efficient co-ordination of all machinery.

The sanitary aspects of the laundry's work include the destruction of organisms in the process of laundering the goods; the sorting of soiled clothes as a source of possible danger to employee and community; the contact of soiled and clean goods as a possible means of infection; the delivery of wet clothes as a medium for bacterial transmission.

Finally, what may be called the social factors comprise the reduction in the life of textile fabrics as a result of carelessness in their use and of their abuse, by the user before laundering, for purposes to which they are not adapted.

A brief survey of the operations employed in the standard processes for laundering white linen and cotton goods will be of value as indicating in some measure just how and when and where these various factors are met. (1) The cold bath comes first; its function is to loosen dirt and to dissolve albumen and starch.[1] It occurs at room temperature and lasts five minutes; the destructive agencies involved are mechanical. (2) The first suds, concentrated, bring into play the detergent action of the soap solution, at a temperature which rises gradually to the boiling point of water through an interval of twenty-five minutes; in addition to the agents of mechanical destruction, we have here the hydroxyl ion, the heat, the detergent and the adulterants, any or all of which may produce a deleterious effect upon the fabric. (3) The warm rinse, at a temperature of some 70 degrees Centigrade, removes the dirty soap solution; it lasts five minutes and involves possibilities of mechanical destruction only. (4) The second, dilute suds bring to bear the final cleansing action of the soap, rising to boiling temperature within an interval of ten minutes; the possibilities of damage are here the same as in the concentrated application of soap. (5) In the bleaching process which follows stains are oxidized or reduced, as the case may be, through a ten-minutes' exposure to the bleaching compound at a temperature of 40° C.; destruction here may be caused either by the hydrochloric acid or by the hydroxyl ion. (6) In the acid rinse, which neutralizes the alkali from the bleach and thus prevents decomposition, there is a 5-minutes treatment at the same temperature as before; and the possibility of damage arises from the presence of the hydrogen ion. (7) The bluing which follows gives the desired degree of whiteness to the washed articles; it



DISPOSITION OF THE LIFE OF A COLLAR
(Approximate Averages)

again lasts 5 minutes at a temperature of 40° and appears to introduce no hazard at all. (8) The final rinse, at room temperature for 5 minutes, leads once more to mechanical wear. (9)-(13) The centrifuging, starching, drying, dampening, ironing and sorting follow, each with its own peculiar variety of hazard of mechanical destruction.

Least generally understood in its intimate bearings is the actual washing process. This involves the combined action of mechanical agitation and the detergent properties of the soap, in the washing machine. The soap is an iono-colloidogen. In solution it is partly hydrolyzed, as proven by test with litmus or phenolphthalin, or by extraction of fatty acid from the solution on shaking with toluene. The free fatty acid thus liberated unites with the salt to form the insoluble acid salt, which aggregates, giving the colloidal suspension, as evidenced by the ultramicroscope.

The soiling of skin and fabrics is ordinarily due to the adherence of dirt particles to substances of a fatty nature that accumulate on the surface in question. The colloidal soap—a suspensoid—removes the grease if there be any, by causing the formation of a stable water-grease emulsoid, thus loosening the dirt particles, which are then removed by adsorption.

In emulsification a large amount of surface energy is produced as a result of the great surface area of both water and grease. As the system proceeds toward equilibrium there is a tendency for this abnormal surface energy to attain a minimum. Since surface energy is the product of two factors, surface tension and surface area, it may be diminished by reducing either the capacity factor of surface area (an alternative which the water by reason of its great surface tension tends to favor by reunion of the drops), or the intensity factor of surface tension, which is tremendously lowered by the colloidal soap. Further, with a lowering of the surface tension, or more correctly the inter-facial tension between the phases of grease and of water, there is at these interfaces a local accumulation of free surface energy which can be lowered by the deposition of substances at the interface. It follows from the second law of thermodynamics that the surface layer will become concentrated at these interfaces, because free energy will thus be decreased. When equilibrium is reached the colloidal droplets will of course resist any change in surface (as the surface energy would change and displace the equilibrium), thus producing a stable emulsion.

The solid dirt particles, loosened by the emulsification of the grease, are now adsorbed by the colloidal soap suspensoid. This is a very effective means of getting the dirt in stable suspension because of the combined effect of electrical adsorption and that due to diminution in surface tension.

The detergents which figure in the laundering process are water, alkalis and soap. A few words may be devoted to discussion of the essential properties which these must possess for most effective service. Since water is used throughout the cycle of operations, we may consider it first. Obviously a supply free from color, odor and suspended matter, and fairly low in dissolved substances, is necessary. The mineral content of water markedly affects the laundering reagents. Since there is continuous fluctuation in the component calcium, magnesium and iron salts in water, periodic chemical analyses of the fluid are of importance, indicating as they do the necessity for continual adjustment and the addition of softening agents.

EFFECT OF "HARD" WATER.

In the classification of waters according to hardness, 1 degree of hardness corresponds to 1 grain $CaCO_3$, or its equivalent in other salts, per United States gallon—that is 0.017 part of the minerals that go to make the water hard. Soft waters are those showing less than 5 degrees of hardness; moderately hard run from 5 to 12 degrees, inclusive; while water in excess of 12 degrees is classified as very hard. The prevalent idea among launderers appears to be that hard water only attacks the soap, and that in all other processes it may be used on an equal footing with soft. This is not the case; there are objections to the use of hard water throughout the laundering operations.

In the first place, as generally recognized, hard water decomposes the soap with the formation of an insoluble curdy precipitate. This not only makes it difficult or impossible to secure full service from the soap, but the curdy precipitate permeates the fabric, forming clots and streaks that are with difficulty removed. And even if this material sets evenly in the meshes of the cloth, it makes the fabric stiff and harsh and causes the heat from the irons to turn it gray. Then there are the economic aspects involved in the precipitation of the curd upon the inner cylinder of the machine, and the waste of 0.17 pound of soap per 100 gallons of water for each degree of hardness. Moreover, the curd interferes with the stability of the emulsion; while in the souring process, if oxalic acid is used to neutralize the hydroxyl ion, the presence of hard water will lead to the deposition of CaC_2O_4 in the fiber of the goods. This substance, which can be removed neither by hot water nor by cold, will result in cleaving of the fiber. Again in the bluing, traces of the insoluble soap precipitated by hard water into the fiber of the goods will adsorb the blue, yielding blue spots and streaks. In the starching, there will be similar adsorption of the starch, with resultant concentrated blotches. In wool scouring the sticky soap clogs the porous structure of the wool, interfering with thorough washing and diminishing the insulation value of the wool in preventing the escape of body heat. And finally, the salts that make the water hard are precipitated in the steam boiler, with consequent waste of fuel, cost of cleaning and repair, scaling, corrosion, priming, and boiler depreciation generally.

"SOFTENING" THE WATER.

Scores of reagents have been proposed for the removal of the objectionable components of hard water. Of these lime and soda ash in combination are in

(Continued on page 400)

[1]See also, in this connection "Malt Extract in the Laundry," Sci. Amer. Suppl., Aug. 12, 1916, No. 2119, p. 107.—Ed.

The Color of Water—II*

A Valuable Compendium of the Literature on a Neglected Subject

By Prof. Wilder D. Bancroft, Ph.D., Cornell

[Continued from Scientific American Supplement, No. 2267, for June 14, 1919, Page 384]

"The Lake of Como was the next water visited. A white surface seen through its waters showed it to be as deeply colored as the Mediterranean, yet the absence of white reflecting particles in its waters and its dark-colored bottom, cause it to appear comparatively dark and colorless. When a quantity of white reflecting particles are artificially mixed up with the water in this lake a fine blue-green cloud was formed, which remained visible for some time amidst the darker waters, and showed that all this lake required to make it brilliantly colored was the presence of white suspended particles in its waters. The waters of Como, in their passage from the lake to form the river Adda, change to a fine blue. This sudden alteration in the appearance of the water is shown to be probably due to the addition of fine reflecting particles to the water on entering the river. Lago Maggiore, compared with Como and the Mediterranean, looks greener than either, but reflects more light than Como.

"The Lake of Geneva, whose waters have been so highly praised by all writers, was next visited, and the explanation given of the coloring of the Mediterranean was found to apply here also. Near Bouveret, where the Rhone enters the lake, all the variety of color phenomena seen in the Mediterranean were repeated. The light colored muddy waters of the entering river, as they stretched far into the lake, represented the whitish waters near shore in the Mediterranean, and where this whitish stream mixed with the waters of the lake, the bright blue-green of the Mediterranean was reproduced, while further out the waters were deeper blue, rivalling in brilliancy those of the Mediterranean. The work done by the waves along th eshores of the Mediterranean in manufacturing the light-reflecting particles, is for the Lake of Geneva, done by the grinding of the glacier mills and streams of the Rhone valley.

"The silt brought down by the Rhone was found to be composed of clean white particles, like fine white sand. Many of the particles are thin polished plates, and when examined by means of a concentrated beam of light, while in suspension in water, are seen to flash brilliantly in the strong light. This white solid matter brought down by the Rhone is constantly being deposited all over the bottom of the lake, and it is this whitish deposit which gives to the Lake of Geneva one of its peculiarities. The light reflected from the whitish bottom causes the water of the lake, all along the shore to appear of a peculiar light blue-green color, and enables us to judge of the depth of the lake at depths far beyond that to which we can see the bottom. We can only see a white surface of 15 cm. square to a depth of about 7 m., yet the light reflected from the bottom affects the appearance of the water at depths far beyond 7 m., showing that light penetrates by diffusion in these waters to far greater depths than it can directly. The brilliancy and beauty of the Lake of Geneva would thus appear to be due to the purity and transparency of its waters, coupled with the presence of an enormous amount of white reflecting surfaces, both in suspension in its water and deposited all over the bottom of the lake, the effect being intensified by the brilliancy of the reflecting particles.

"The color of the water in Lake Bourget was found to be similar to that in the Lake of Geneva, though at the time it was visited it was slightly more turbid. A white surface could not be seen to so great a depth as in Geneva, and the water, even in the middle of the lake, when examined by means of a concentrated beam of sunlight was found to be very full of suspended light-reflecting particles similar to those brought down by the Rhone. The examination of the water in these lakes was confined to the colored surface experiments, and to a spectroscopic examination of the internally reflected light. The results were all similar to those in the Mediterranean.

"In the beginning of autumn the sea off the west coast of Scotland, near the village of Ballantrae, and also in Brodick Bay, was visited, and the water examined by means of submerged colored surfaces, and by means of the spectroscope. The water was here found to be much greener than any previously examined. A large quantity of this water was filtered, when it was found that most of the suspended particles were fine grains of sand. From this it is concluded that the greenness of our northern seas is in part due to the reflecting particles being yellow, and the reflected light, therefore, deficient in the more refrangible rays. These yellow sand particles not only explain part of the greenness of our northern seas, but they also explain their comparative darkness and deadness, the yellow sand particles reflecting so little light. The importance, however, of even these bad reflectors was very evident during the time the observations were being made. It was noticed that the water was much more brilliantly green during and immediately after an inshore wind, and when the filter showed the water to have a good deal of sand in suspension, than after a calm, when many of the particles had settled out. Some water collected about a mile seaward from Ballantrae was examined in a glass tube 7½ m. long, and was found to be of a blue-green color.

"The water of Loch Lomond was next examined, and found to be a perfect contrast to any previously described, being of a color nearly complementary to that of the Lake of Geneva. A white surface seen through its waters appeared yellow, and the submerged colored surfaces showed its waters to have their greatest absorption for the rays of the violet end of the spectrum. Its waters reflect a slightly yellowish light, its spectrum being brightest in the yellow. This water is so deficient in reflecting particles that its brightness is never greater than what we call brown. If it was supplied with abundant reflecting particles Loch Lomond would be a yellow lake.

"Well waters were also examined for color by placing them in long tubes, and looking through the water at white and at colored surfaces. The tubes were in pieces, so that they could be fitted up in lengths of from 3 m. to 15 m., to suit the transparency of the water under examination. The tubes were fixed horizontally, and at a convenient height for looking through them, and the water to be tested was poured in till the tube was half full, so that by looking through the upper half of the tube the colored surface could be seen, and through the lower half the effect of the absorption of the water on the color, and on the brilliancy, of the transmitted light. The transmitted light was also examined by means of a spectroscope.

"The colors of the different water were found to vary greatly. One sample was of fine blue, others were green-blue, some green, while others were of colors between green and yellow, but all were of colors between blue and yellow. It was observed that the more transparent a water was, the nearer its color was to blue. Scarcely any light could be seen through 7 m. of any of the yellowish waters, while through this length all the bluish waters were quite transparent, and the spectroscope showed that some of the waters transmitted almost the entire light of the blue end of the spectrum, and only stopped the rays at the red end. When one of the bluish waters was examined in a tube 15 m., or nearly 50 feet long, it appeared of a fine blue-green as transparent as a piece of glass.

"Only a very little relation could be traced between the color of a water—when tested in long tubes—and its suitability for dietetic purposes.

"The *cause* of the color of water has been a frequent subject of speculation. Every substance which has been discovered in water has in turn been suggested as the cause of the color. When no useful purpose could be given for its presence, it was told off to do the ornamental, and make the water beautiful to the eye. All these speculations assume that the color is due to some impurity in the water. This, however, is obviously begging the question. It is first necessary to find out whether water has any color in itself, and what that color is, before we can say anything about the effect of impurities. As it would be impossible to prepare absolutely pure water, and as we might still be in doubt as to whether any color seen in purified water was due to the water or to the impurities, the following method of experimenting was adopted: Distilled water was prepared in two sets of apparatus; in one set the condensing tube, the collecting bottle, and the testing tube were all of glass; in the other set they were all made of brass. If the waters prepared in these two sets of apparatus have the same color, then the probability is that the color is due to the water, as the impurities will be different in the two samples, and they would probably give different colors. The result was, the color of the samples of water prepared in both sets of apparatus was the same—namely, blue. This conclusion was further confirmed by preparing another sample of the water, and condensing it this time in a platinum tube. The water so prepared was also found to be of a fine blue. All three samples were almost exactly the same color as Prussian blue. Standards of color were kept with which the different samples of water were compared, both for the color and for the amount of the color. As all the different samples of distilled water—after the apparatus was thoroughly purified—had the same color and amount of color, it seems almost certain that water is a blue transparent substance, and that the color in these experiments could not be due to impurities, which must have varied both in kind and in amount in the different samples of water. Further, as the amount of color in the Mediterranean water, and in the bluish well waters, was as near as could be judged the same as in pure waters, it does not seem necessary to call in the aid of impurities to account for the blue color seen in the lakes and seas, the color being principally due to the water itself, and the different substances in solution, instead of making the water blue, tend to change its proper color and make it green or yellow.

"The addition of impurities to water seems generally to change its color from blue to green, or to yellow, though there seems to be no reason why some impurity may not change it to a deeper blue. The selective-absorption of the water remains the same, while the impurities add their selective-absorption to that of the water, and while they change the color they also decrease its transparency. This explains why it is that the yellow well waters are so much less transparent than the blue. This must necessarily be so, as a very small depth of water destroys the rays which give yellow, and the transparency of yellow waters can only be the transparency of water for yellow light, which is very much less than for blue light. No attempt was made to find out what the different discoloring substances in water are. The task would evidently be an endless one, and of little value.

"The effect of the light reflected from the surface of the water is then referred to. It is shown that when the sky is covered with white clouds, the surface reflection is so strong as to mask the color of the water, and that when the sky is deep blue the sky-reflected light intensifies and deepens the apparent color of the water. The importance of the surface-reflected light is best seen when the sky is covered with clouds, and glowing with a color different from that of the water, as at sunset when the clouds are richly colored all over the sky and deeply down towards the horizon. The water will then, especially if calm, appear like a sea of molten metal glowing with sky-reflected light, so powerful and brilliant as entirely to overpower the light internally reflected by the water.

"Pure water having been shown to be perfectly transparent to the more refrangible rays, and as it absorbs the red rays, water, when looked at from the side on which the light is falling, must necessarily be dark, and cannot reflect any perceptible amount of blue light. We must, therefore, look to the solid particles in suspension in the water as the cause of the light reflected by water, and while the selective absorption of the water principally determines its color, its brilliancy is entirely determined by the suspended particles. It is shown why it is that though we have waters of many colors, yet we only observe the color when it is blue or green, and never when it is yellow. Among other reasons given is the much less brilliancy of yellow waters, this less brilliancy being due to the less transparency of the yellow waters compared to blue; only the reflecting particles near the surface are active in the yellow water, whereas the particles to a considerable depth in the blue can reflect their light to the surface. This is one reason why Loch Lomond is so much darker than the Lake of Geneva. Loch Lomond certainly has fewer and less powerful reflecting particles than the Lake of Geneva, but it is darker also, because only the particles to a much less depth can reflect their light to the surface.

"The waters of our northern seas, when provided with proper reflecting particles, such as air-bells and white particles, are shown to be much bluer than they generally appear. The brightness and blueness of the waters off the coast of Cornwall are shown to be due to the beaches along this coast being at many points covered with a whitish-colored sand, which gets mixed up with the water by the action of the waves. As the water of the sea is constantly circulating, it seems impossible that the same water can be one color at one

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place, and a different color at another, but we can easily see how the different colors and degrees of brilliancy can be produced by the color and the amount of suspended matter at the different places—where the water is mixed with whitish particles being bluish, and where mixed with yellow particles appearing greener—while its brilliancy is determined by the amount of suspended particles which may be present at the time in the water.

"In conclusion, a lake in the Cordilleras is referred to as combining all the conditions necessary for producing fine and brilliantly blue colored waters. The traveller in describing this lake says: 'Its waters were of the most extraordinary brilliant blue I ever beheld.' From the description, this lake is in many respects like the Lake of Geneva. It is provided with an abundant supply of pure glacier water, free from discoloring impurities, but laden with abundance of white-reflecting particles, whose presence is evidenced by a 'white strip' around the lake."

In a letter to Professor Tait, dated Mentone, April 14, 1882, Aitken[5] says:

"Since coming here this time I have tested the sea with the polariscope and with the spectroscope. With an instrument by Hoffman, which gives colored bands with polarized light, I have been able to detect small, but decided indications of polarization in the light internally reflected by the water, the surface reflection being, of course, cut off when the observation was made. At present I think the polarization is due to regular reflection from the polished surfaces of some of the particles, which are seen to glance brightly in concentrated sunlight.

"I have also detected an absorption band in the green of the spectrum of the light internally reflected by the Mediterranean water. This band is much more distinct in water where there are but few reflecting particles, and the light undergoes a great amount of selective absorption. At about a mile from shore, where I could see a white surface 6 inches square at a depth of 16 metres, the absorption band was quite distinct, but became less and less as I approached the shore, where there was more matter in suspension and the water less transparent, but the spectrum more brilliant. I cannot say whether this band belongs to water or to salt, or to what it is due, never having noticed it before; but I never examined water so transparent, and where the light had undergone so much absorption."

Subsequently to Aitken, but apparently independently, Spring[6] made a thorough and interesting study of the color of water. "Water in large masses always appears colored to us; but the color is not always the same and the tints are rich and vary enormously. The Mediterranean is the most beautiful indigo; the Atlantic is sky-blue; the Lake of Geneva is famous for the beauty of transparency of its azure waters; the Lake of Constance, the Rhine which flows from it, the Lake of Zürich and the Lake of Lucerne are just as transparent, but the waters are more green than blue. The little Kloenthaler Sea near Glaris can scarcely be distinguished from the surrounding fields, the water is so near the color of the grass on the banks. Among the more deeply colored waters I will mention only the Lake of Staffel near Murnau at the foot of the Bavarian Alps. On the day that I saw it, the water seemed absolutely black, although perfectly clear when seen in thin layers."

"Bunsen was the first to deny that water was colorless. Struck by the greenish-blue tint of the hot water of the Icelandic geysers, he poured pure water into a glass tube two meters long and blackened on the inside. He was able to detect a faint blue under these circumstances and concluded that water is actually blue. The other colors besides blue must then be due to foreign substances or to the reflection of light from a colored background. Bunsen did not go into details as to the way in which the color changes would occur. Some twenty years later, Tyndall put forward the view that the blue color of the sky is due to the scattering of light from numberless, colorless particles suspended in the air. This suggested to Soret[7] that the blue color of the Lake of Geneva might be due to similar causes and he found that the water sends out light polarized perpendicularly to the refracted rays of the sun. The analogy between the experiments of Tyndall and of Soret is so close that one may claim the existence in the water of transparent particles which may be the cause of the color. Hagenbach[8] repeated these experiments at the Lake of Lucerne, getting similar results. The following year, Tyndall[9] himself examined water from the Mediterranean and from the Lake of Geneva, sent to him in London. When a beam of light was passed through them, it became blue and the blue light was polarized. These waters are therefore not optically empty. These experiments seem to show conclusively that the water itself is colorless, contrary to the opinion of Bunsen; but this is not necessarily true. Soret himself points out that on cloudy days there was not a trace of polarization and yet the lake was blue. This is sufficient to prove that reflection is not the sole cause of the color of the water. Further, if the blue of the water were due to exactly the same cause as the blue of the sky, the light transmitted by the water should be a crimson red at least as intense as that which lights up the tops of the high mountains or the thin clouds through which pass the rays of the rising and setting sun. This is not the case, however, as Tyndall himself points out. Also Father Secchi[10] has determined the absorption spectrum of sea-water and finds that the red and yellow are lacking. It is also well known to people who have been down in a diving-bell or who have visited the Swiss grottoes cut in the ice of the Rhone or the Grindewald glacier that the light is bluish. There is so little red that faces appear livid.

"In 1848 H. Sainte-Claire Deville[11] analyzed a large number of natural waters and he observed that the blue waters of the Swiss and the Jura lakes, when evaporated, leave residues which are only slightly colored, while the green waters of the Doubs and the Rhine contain a considerable amount of organic matter, so that the soluble salts were colored distinctly yellow when the water was evaporated. From this it appears that the green waters and still more the yellow or brown ones may owe their color to the presence of a small amount of yellow mud. If pure water is really blue, a small amount of yellow coloring would be sufficient to change the color to green or even to yellow. This same idea crops up again in a much later paper on the color of water by Wittstein.[12] This chemist analyzed the waters of many of the brooks, rivers and lakes of Bavaria, and thought that he had proved that the brown or yellow waters contain more organic matter and are less hard than the green waters. He explains the different shades of natural waters by assuming, with Bunsen, that pure water has a blue color, that the mineral substances dissolved in the water have no effect on the color, and that the different colors are due chiefly to dissolved organic matter. These organic substances are brown in color and are essentially humic acids. They are kept in solution by the presence in the water of a sufficient amount of alkali salts. On this hypothesis a water containing very little organic matter would be practically blue, while the blue color would change continuously to green, yellow, brown and black, as the amount of organic matter increased.

"It is worth while to examine this hypothesis. At first sight it seems an excellent one because it rests apparently on definite facts; but it is easy to show that the hypothesis does not follow necessarily from the analytical data. It is therefore without any firm foundation and does not solve the question. I shall not stop to discuss the question whether the organic matter is brown when it is in solution or whether it becomes brown and even black during the evaporation. In view of the description of the evaporation given by Wittstein, it seems probable that the deep color is due to the action of heat.[13] Such a discussion would be a waste of time. Let us rather consider the analytical data as shown in Tables II and III.

TABLE II.
Brown waters (p.p.m.).

	Organic Matter.	KOH and NaOH.	Ratio.
Ily	37.8	10.1	3.74
Regensee	21.4	15.4	1.39
Rachelsee	43.3	18.4	2.35
Ohe	111.4	12.8	9.0
Steckenbach	55.0	9.5	3.68
Höhenbrunnfils	59.7	7.8	6.50

TABLE III.
Bluish-green waters (p.p.m.).

	Organic Matter.	KOH and NaOH	Ratio.
Isaar	39.6	9.8	4.04
Brunnthaler Spring	65.6	4.7	13.97

"These figures show that the color of the waters stands in no direct relation, either to the amount of organic matter or to the alkali concentration. The green Isaar contains more organic matter than four of the brown waters and also more alkali than two of them. The waters from the Brunnthaler spring show similar relations. It is also worth noticing that Wittstein gives no analysis of a really blue water and consequently there is no real basis for a comparison. He also makes the general rule that greenish-blue waters are hard because of the small amounts of alkali which they contain while the yellow or brown waters are soft, and then he admits that the rule holds only for running water because the waters of the Lake of Starnberg are extraordinarily soft although green. I add that the blue waters of the Rhone, where the river flows out of the Lake of Geneva, are also soft, as is shown by the large number of laundries along the river. It is evident that the color is not different for running and for stationary waters. Wittstein's hypothesis therefore seems insufficient. It may be true, however, for some very deeply-colored waters because if these really hold a colored material in solution or in suspension, their color ought to be dark.

"Schleinitz[14] attributes the change in the color of sea-water to the greater or lesser amount of dissolved salts. He noticed sudden changes in the color of the sea when he was crossing from Ascension towards the Congo on board the *Gazelle* in 1875. On August 23, 5° south latitude and 9° west longitude, the sea changeed from blue to greenish. On the twenty-fifth it was bluish and on the twenty-sixth in 5.5° south latitude and 5.5° west longitude, the sea became again deep green, changing to a dirty green and then to a brown as the ship approached the Congo. Later, on the voyage from the Congo to the Cape, the sea became green, then bluish-green, and finally bright blue. Each time that the sea became greenish Schleinitz found that its specific gravity decreased while there was an increase when the sea became blue again. From this he concluded that the bluest water contained the most salt and that the salt was the cause of the color. Although this observation led to a false conclusion, it confirms some of the results which I have found and I shall come back to it again.

"It is worth noting that in the waters of the Lake of Neufchatel and also in the ice from the lake, J. Brun[15] found an alga which is green, orange, red or brown, depending on the different phases of its development, and turns black after death. Its presence might well affect the color of the water."

In order to determine the color of pure water Spring took two tubes five metres long and about four centimetres inside diameter, coated with black on the outside. When distilled water from the laboratory supply was put into the tubes, the color was a light green very like that of a dilute ferrous sulphate solution. Some days later the tubes were filled with freshly-distilled water and the color was a fairly pure sky-blue. After standing about seventy hours in the tubes this water was as green as the first without having lost anything of its clearness. This preliminary experiment shows that the distilled water of the laboratory is far from being pure and contains substances which undergo changes, in that a blue water becomes green slowly. These foreign substances may be inorganic or organic; it is not impossible that they are living organisms. The following experiment is evidence in favor of this. "The two tubes were filled with distilled water but one ten-thousandth of mercuric chloride was added to one tube. At first both tubes where blue and there was no perceptible difference between them. After six days the water in one tube had become green, while the water containing the mercuric chloride had not changed in color, and even after three weeks the blue color was the same. Mercuric chloride was then added to the green tube and after three days a distinct change towards blue was noticeable. At the end of nine days no further change took place and the water was distinctly bluish-green; but it never returned to a pure blue. Since mercuric chloride is one of the most toxic substances known, especially for minute organisms, there is certainly reason to believe that living organisms are to be found in the distilled water of the laboratory and that the water also contains the food necessary for the development of these organisms. . . .

"Stas[16] has shown that rain water or spring water, if distilled twice, gives a liquid which volatilizes without leaving any residue if evaporated at once in a platinum vessel. If this same distilled water is kept several days and then evaporated, it leaves a noticeable brownish-yellow residue, which burns completely at red heat in the air. Stas concluded that distilled water contains volatile organic matter which becomes non-volatile spontaneously in the course of a few days. This conclusion fits in well with my ob-

[5]Aitken: Proc. Roy. Soc. Edin. 11, 472 (1882).
[6]Bull. Acad. roy. belg., (3) 55 (1883).
[7]*Ann. Chim. Phys.* xvii (4), 517 (1869).
[8]*Ann. Chim. Phys.* xx (44), 225 (1870).
[9]*Naturforscher*, iv, 1, (1871).

[10]*Naturforscher*, i, 149 (1868).
[11]*Ann. Chim. Phys.* xxiii (3), 32 (1848).
[12]*Vierteljahresschrift für praktische Pharmacie* xx, 342 (1861).
[13]During the evaporation insoluble brown flocks form and become even darker. If heat changes the solubility of the organic matter, it may also affect the color.

[14]*Naturforscher*, viii, 59 (1875).
[15]Jahresbericht über Chemie, 1880, 1512.
[16]Bull. Acad. roy. belg. x (2), (1860).

servations. So long as the distilled water contains the dissolved organic matter in a volatile state, the water is blue by transmitted light, but it becomes more and more green as the dissolved matter becomes changed by the action of organisms and ceases to be volatile. A similar fact has also been observed by P. Glan[27] in his studies on the absorption of light. He calls attention to the difficulties due to the presence of foreign matter which it is almost impossible to remove. He notes that after distilled water has stood several days in a closed vessel, it lets less light through and appears as though turbid.

"These preliminary experiments show that the distilled water of the laboratory is absolutely unfit for experiments like these, for it changes on standing. Stas[28] has pointed out a method for obtaining pure distilled water. It consists in distilling spring water with a mixture of manganate and permanganate of potash, taking care to condense the vapor in a platinum cooler. Water prepared by this method contains no trace of non-volatile organic matter either when first distilled or later. I have made use of this method, taking all sorts of precautions. Ordinary water was first boiled with alkaline permanganate for four hours in a glass vessel. It was then distilled twice in an apparatus made entirely of platinum and was collected in a closed silver flask out of contact with the air. In order to clean the apparatus, three litres of water were distilled and thrown away. Then the first fifth of the final amount of water distilled was used to wash the surface of the silver flask. I have satisfied myself that water thus prepared is volatile without residue. To show this I have polished the inside of a platinum crucible with precipitated and dried silica so as to get a brilliant surface on which the least trace of residue would show. When the water was evaporated in this closed crucible, no visible deposit could be detected on the mirror surface, and I believe that one cannot say that such water contains any non-volatile material.

"When this pure water was poured into the tubes it is hard to describe the purity of the blue color which was seen. The only thing that could be compared to it is the most beautiful blue of the sky on a clear day at the top of a high mountain when one is far above the mists rising from the ground. When the tubes were allowed to stand for two weeks, no change in the purity of the blue could be detected. This premanence of color is perhaps a proof of the extreme purity of the water. I have tested this water by the Tyndall method, focussing a magnesium flame on one point in the tube by means of a concave mirror. Unless my imprefect apparatus has led me into error, the luminous cone was scarcely visible in the liquid. It was difficult for me to say whether its path could be detected or not. Whatever one may think on this point, it appears certain that the purest water which one can prepare is a wonderful blue if one looks through a sufficiently thick layer. Is this color peculiar to the water or is it due to reflection of the incident light as is the case with the blue of the sky? I think that everybody will reject any hypothesis as to the color being fortuitous. Under the conditions as arranged, one looked through the water along the axis of the tubes in the direction of the illuminating ray. If the blue were due to the reflection of light from otherwise invisible particles, the maximum intensity of the blue color should be found in a direction perpendicular to the luminous ray, which is just the opposite to what occurs actually. Further, on this assumption the transmitted light ought to be red or mixed with red, which is not the case, the purity of the blue proving the absence of red. In addition I have made another experiment which seems to me conclusive. If the blue color of water is not characteristic of this substance and if it is due to the presence of foreign matter coming from the air, it follows that any liquid would be blue like the water if treated in the same way. In other words, there could be no colorless liquid. I have distilled five litres of amyl alcohol for several weeks in a glass vessel and exposed to the air of the laboratory. In spite of this careless treatment and in spite of the fact that the liquid had taken up a good deal of dust, there was no sign of color in the tube when the layer was five metres in thickness. Lack of material prevented an examination of a layer ten metres in thickness.

"At first I tried crystallized acetic acid and absolute ethyl alcohol, but these substances were yellow when examined in a five-metre layer. This yellow color disappeared gradually as the layer was made thinner without showing either green or blue. I am not certain, however, that these substances are really yellow because acetic acid and ethyl alcohol are apt to contain empyreumatic substances which are very difficult to remove. It seems certain from these experiments that the purest water one can prepare is not colorless but has a blue color due to an absorption in the yellow and not to a reflection of the incident light.

"We can now discuss the causes of the different colors of natural waters. Since analysis has not shown in any definite way the presence of green, yellow or brown matter in the green waters, and since Wittstein himself admitted the absence of any yellow mud in the green water of the Lake of Starnberg, a different line of attack must be chosen. Five litres of pure, blue water were treated with a few grams of a lime containing no iron and obtained by calcining Carrara marble. This lime water was quite clear after standing for five days. A solution of carbon dioxide in water was added until a precipitate was just barely visible. When placed in the tubes the water was then absolutely opaque. It would not have been any different if ink had been poured into the tube instead of this calcareous water. The water was taken out of the tube, diluted with pure water, and treated with carbon dioxide to precipitate the calcium carbonate and then to redissolve it as bicarbonate. Every now and then the current of carbonic acid gas was cut off and the water was examined in the tubes. The original opacity disappeared slowly and the light which came through was first brown, then pale brown, yellow, green, and finally the liquid became blue again though with a touch of green after the carbonic acid had been run in for eighteen hours. With the combined action of carbon dioxide and calcium carbonate it is thus possible to reproduce all the colors of natural waters from complete opacity to a greenish-blue.

"As a further confirmation I have prepared a saturated solution of calcium carbonate and carbon dioxide in pure water, which was green when viewed through a five-metre layer. I then placed this in a vacuum to draw off some of the carbon dioxide and to cause a dissociation of the bicarbonate, after which the liquid was examined in the tube. Each time this was done, the color became more yellow. The green disappeared soon and finally the tube became opaque. A drop of hydrochloric acid brought back the greenish-blue color. Similar results were obtained with barium hydroxide and carbon dioxide. With excess of the latter the water became brown, yellow, green and bluish-green. Using hydrochloride or nitric acid instead of carbon dioxide the color changes are obtained more rapidly. A solution of sodium silicate containing a little free silicic acid was opaque in a five-metre layer and brownish-yellow when a metre in thickness. When a concentrated solution of caustic soda was added to dissolve the free silicic acid, the yellow color disappeared. Pure water holding in suspension a little amorphous silver chloride is opaque or yellow, depending on the thickness of the layer. Ammonia dissolves the precipitate and removes the opacity or the yellow color.

"These experiments warrant the drawing of several conclusions. A luminous beam of given intensity will not pass through a sufficiently thick layer of a liquid holding enough particles in suspension even though these are transparent or colorless. A tube containing suspended calcium carbonate, barium carbonate, silica or silver chloride may be opaque to diffused daylight and yet let through light from the sun or from burning magnesium. The physical state of the suspended particles does not affect the phenomenon. If one pours water into ethyl alcohol containing a little dissolved amyl alcohol, a persistent turbidity is caused, due to the minute drops of amyl alcohol which do not dissolve in the water. By varying the amounts of ethyl alcohol and water for a given amount of amyl alcohol, one can change the degree of turbidity and make it as small as one pleases. It is evident that each drop of amyl alcohol is liquid and transparent, and yet such a turbid liquid is opaque for a definite thickness of layer and intensity of light; it is yellow if the light is more intense and colorless under a very powerful light. Similar changes take place if the intensity of the light is kept constant and the thickness of the layer decreases. The reason for this is easy to see. When a ray of white light passes through a medium which holds in suspension an infinity of reflectors, each simple wave forming the white light is reflected independently of the others. If there is not total reflection the intensity of each wave will decrease with increasing thickness of the layer. Since the different colors constituting white light have not the same luminous intensity, the weakest will disappear first and the color at the ends of the spectrum, the red and the violet, will be eliminated early while the yellow, which is the most intense to our eyes, will outlast the others though weakened itself. One could probably explain the phenomenon in another way and say that when white light passes through an absorbing medium the yellow is the last to disappear.

"I will add that it is not necessary to have a liquid holding reflecting particles in suspension. A similar phenomenon occurs in the air. Everybody has noticed that the shadow projected by smoke or by condensing vapor on a white background is not merely gray; it always has a yellow-brown color to which one gives the name of yellow smoke or brown smoke. A liquid holding a colorless substance in suspension appears white solely because of the reflected light. Milky lime water, though very white, is as opaque as ink, and the white color shows merely that the light which illuminates it does not pass through it.

(To be continued.)

[27]Pogg. Ann. cxii, 66 (1870).
[28]Mém. Acad. roy. belg. xxxv, 110 (1865).

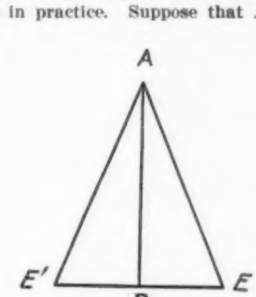
The Light-Giving Power of the Stars

By Henry A. Peck

STANDING on a clear night and looking at the stars sparkling above us, it is almost impossible to realize that many of them are bodies larger than the sun. If, for example, we could be brought as close to Capella as we are to the sun, the flood of light and heat would be past endurance by all forms of life, developed under present terrestrial conditions, and fitted by inheritance to exist in their present environment.

The principles which underlie the problem of comparing the light of the sun with that given by some of the stars are quite simple and easily understood. The two factors to be considered are the distance of the star from the earth in terms of the distance of the sun, and in connection with this, the nature of the scale by which the comparative light of the sun and the star is measured.

To find the distance of a star is theoretically simple, although it may be quite difficult to secure accurate results in practice. Suppose that A is the position of the star, B is the position of the sun and E and E' the two extremities of the major axis of the orbit of the earth. The angle BAE is called the annual parallax of the star. It will be readily seen that it is one-half of the angular displacement of the star in space as the earth moves around the sun from E to E' In no case is the parallax so large as a second of arc and it is only within comparatively recent times that it could be measured with anything approaching accuracy. Since the angle is so small the distance AB is nearly equal to the distance AE and they are both equal to $\frac{206265}{p}$ where p is the parallax, the unit of distance is the distance of the sun from the earth and the numerator is the number of seconds in a radian.



To find the distance of a star

As the apparent light varies inversely as the square of the distance, any star at the same distance as the sun from the earth will shine with $\left(\frac{206265}{p}\right)^2$ as much light as it does in its present position. Applying this principle to the case of Capella, whose parallax is only 0."08, it is found that its light would be increased 6,640 billion-fold. As fairly reliable measurements place the present light of the sun at about 50 billion times that of Capella, it follows that the star would shine with the light of about 133 suns if viewed from the same distance. If there was an absorption of light in space, this ratio would be disturbed.

But it is possible to view the problem from another angle and to produce a simple formula by which not alone the light of Capella but that of other stars may be compared with the light of the sun. According to modern methods the comparative brilliancy of the stars is measured according to a system of magnitudes, in which the variation from one star magnitude to another is in a geometrical ratio, whose value is $(100)^{\frac{1}{5}}$. In this magnitude scale, a star of the sixth magnitude is one which is barely visible to the naked eye and a star of the first magnitude is one which gives 100 times as much light. A star which is one magnitude brighter than the first magnitude is of the zero magnitude, and if still brighter is of some *negative*

(Continued on page 400)

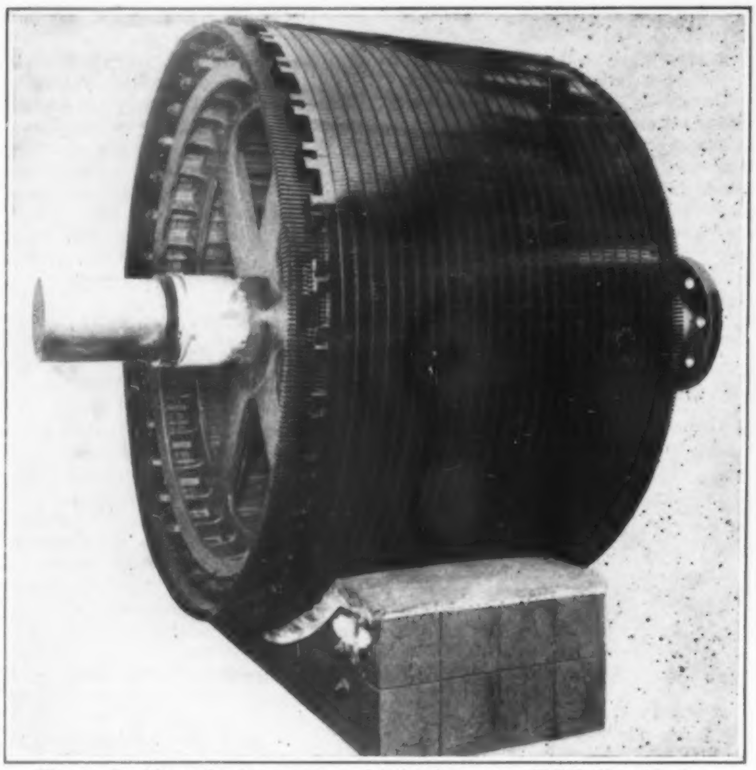


Fig. 1—Double-squirrel-cage rotor of induction-motor, U.S.S. New Mexico

Fig. 2—Stator of induction-motor completely wound, U.S.S. New Mexico

Electric Propulsion for the U. S. S. New Mexico—II*

The Single-wound, Variable Speed Motor, with Double-squirrel-cage Rotors of the New Mexico

By A. D. Badgley

For a number of years the application of electric drive to large ships has been seriously considered by many electrical engineers. Boats of small power had been driven by direct-current motors; but for large power installations the induction motor, receiving its supply from a high-speed turbine-generator where a maximum efficiency with minimum weight and size could be obtained, seemed very attractive.

As a result of this study, the United States Navy Department became interested and decided to equip a collier with electric drive and give it a thorough trial. As the requirement was for a single speed, a simple induction motor of the familiar land type with polar-wound secondary and slip-rings was used so that a resistance could be inserted in the rotor circuit for starting and reversing.

Two of these motors were built during 1911-12 for direct connection to the propeller shafts of the collier *Jupiter*, a twin-screw boat of 20,000 tons displacement having a speed of 14.5 knots. This equipment gave greater efficiency than previous types and operated with entire satisfaction. After an exhaustive trial during which the ease of operation and improved maneuvering qualities of this boat became very apparent, the decision was made to obtain the advantages of electric drive for battleships in the United States Navy.

The *New Mexico*, a 32,000-ton ship now regarded as the most powerful battleship afloat, was selected to be the first of the electric-driven fighters. For this application the highest possible economy was desired at the two most important speeds, viz., high speed with full power at 21 knots, and medium speed at 15 knots where the maximum cruising radius without re-fueling is of the greatest importance. With these requirements, it was evident that for the most economical operation a changeable-pole motor giving a speed ratio of 2:3 was desirable on each shaft, the four motors at full speed taking power from two generators, and when cruising from one generator. By changing the poles on the motor, the proper speeds of the screw are obtained with a maximum speed of the generator thus giving low steam consumption on the turbine in both cases.

Previous to the time of designing the motors for the *New Mexico*, a 2:1 speed ratio had been extensively used with single windings in stator and rotor. All other ratios of speed had been secured by using two windings in the stator, one for each speed, rather than a single winding with a large number of stator leads, which would cause too great a complication of the control. The double winding has the disadvantage of requiring a larger motor, as only half of the copper is in active use at either speed.

Since the motors and generators of the *New Mexico* were to be especially built to operate together, more liberty in design was allowed. A new type of winding was designed, the coils of which were so grouped that a change in the connection at the motor terminals would give a balanced quarter-phase distribution for either 24 or 36 poles. This gives a simpler control than if the motor were wound three-phase. In addition, since the four motors receive power from two generators at full speed, and one generator at cruising speed, the best combined operation is obtained with a decreased voltage on the 36-pole combination. This also works out best for a quarter-phase winding; by connecting the generators in square connection for high speed and parallel connection for low speed, the correct ratio of operating voltage is obtained. By this scheme of connection eight terminals were brought out of the motor, though only four-line leads were required.

The torque requirements derived from actual experiments on the *Jupiter*, supplemented by tank trials, showed that a resistance inserted in the rotor winding would be required only for a few seconds at a time, that is, during starting or upon reversal in order to obtain quick possession of the screw and bring it up to speed. With this in mind, a double-squirrel-cage type of motor was adopted thus eliminating the rheostat. The outer high-resistance, low-reactance winding takes the place of the rheostat when starting and reversing. The inner low-resistance, higher reactance winding is the running winding when the motor is up to speed. The inductive action between these two cages is such that when the frequency in the rotor is high, as at starting or reversing, the current is choked back in the low-resistance winding thus forcing a large percentage of the current through the high-resistance and producing adequate torque. As the motor speeds up, the rotor frequency drops off and the inductive effect on the inner winding decreases, allowing the current to increase with a corresponding decrease in the outer winding until at slip frequency practically all of the current passes through the low-resistance cage. By this construction, the torque advantage of a high-resistance rotor is obtained with the low slip and high efficiency of the low-resistance type of rotor when at full speed. The winding diagram and torque characteristics of these motors appear elsewhere in this magazine.[1]

The design of motors for use on shipboard differs very materially from that of ordinary commercial motors. For the latter, the question of size and weight is of minor consideration while for ships it is a vital one. On land, a motor is usually operated from a transmission system having a fixed source of supply and the power-factor of the motor is of great importance. A low-power factor load requires a larger percentage of the generator and line capacity than does a high one. The best design for the commercial motor of high power-factor usually requires a machine with as large a ratio of diameter to length as possible, without undue sacrifice in cost and efficiency.

For marine work this standard of design can be greatly modified. First: the power demanded from the motors can be very accurately determined and, except for a slight variation due to the depth of the propellors, roughness of the sea, and steering, it is constant for any given speed.

Second: the motors are supplied with external ventilation instead of being self-ventilated and the amount of air forced through the motors for cooling can be varied with the load if so desired. These conditions taken together allow of a much smaller motor being used.

As the motors and generators are close together, the effect of the motor characteristics on the transmission system can be ignored and they can be designed directly for each other with special attention to the combined characteristics of the units. To further reduce the size and weight of the equipment, the comparatively low-speed motor should be smaller in diameter and longer than is usual, and the resulting lower power-factor should be taken care of by increasing the size of the high-speed generator because of greater excitation necessary.

The motor with a smaller ratio of diameter to length also gives greater efficiency due to the decrease in the fixed rotation losses and a greater percentage of active copper in the slots compared to the inactive copper in the end connections. Figs. 1 and 2 show the small diameter and great length of those motors. The ratio of diameter to length in this case is 2:1, whereas in the land type this ratio would be about 4½:1.

In addition to reducing the size by designing a lower power-factor machine and using all the active material at both speeds, a minimum of weight with ample strength was obtained by the use of steel throughout for the mechanical structure. The stator frame was made up of a series of circular rings of I-beam section with dovetail ribs attached. Each ring is of sufficient strength to support its section of punchings, and is held in position by being riveted to

*General Electric Review, Schenectady, N. Y.

[1]General Characteristics of Electric Ship Propulsion Equipments, by E. F. W. Alexanderson, *Genl. Elect. Rev.*, April, 1919, v. 22, p. 224 ffg.

Fig. 3—Laminations assembled and clamped in the induction motor stator frame ready for the insertion of the winding

rigid steel feet. Boiler plate extending the full length of the frame was rolled to fit the I-beams and was securely riveted to them, making a very rigid and compact structure. By increasing the number of circular sections any length of frame desired can be made up. Holes for ventilation purposes were cut in the top half of the frame through the boiler plate. In this frame-work, the stator punchings were assembled on dovetail ribs and clamped with steel finger flanges held in place by bolts and studs. See Figs. 3 and 4. The rotor spider was made in two sections along the shaft to obtain a better flow of metal in casting than is possible with a single section. Dovetails were cut in the spider ribs on which the rotor core was assembled, and further secured by steel pins driven through reamed holes in the punchings just over the dovetails, and clamped between rings held in place by studs passing through the rotor between the dovetail ribs and back of the rotor punchings.

The stator winding was made of form-wound coils of rectangular wire carefully moulded and insulated principally with mica and with a special varnish treatment to prevent damage due to moisture or salt accumulation on the winding. This insulation is capable of withstanding a higher temperature in the core than is usual for induction motors.

After insulation, the coils were assembled in open slots and held with wedges in the usual manner. The coil ends were laced tightly to an insulated steel ring, holding them rigidly in position as shown in Fig. 4.

The double-squirrel-cage secondary winding, Fig. 6, consists of two entirely separate cages, the bars in both cases being driven into close fitting slots without insulation to allow the heat generated in these windings to flow freely by conduction into the rotor iron.

Fig. 5—Induction motor rotor with two sets of winding slots ready for the insertion of the bars of the double-squirrel-cage winding

The outer cage is of high-resistance metal short circuited by copper end-rings, into which the bars are brazed. This ring also is in intimate contact with the rotor punchings. Thus, during reversal when the greatest amount of heat is generated in this winding, the heat storage of the rotor iron is taken advantage of and the temperature of the bars kept down to a very conservative value.

The end-ring is of special design made up of short sections connected together by expansion joints of laminated copper, thus allowing expansion due to heating to be taken up between sections around the periphery and limiting the possible bending effect on the bars to a few mils instead of the comparatively large value which would exist if the ring were made solid and the diameter allowed to change.

The inner cage is of copper electrically welded to a copper short-circuiting ring made of a single piece of bar copper rolled in circular form to accurate size and the two ends welded together. It was not necessary to break up this ring, as the inner winding was designed to remain cool under all conditions of running, the double-squirrel-cage design allowing full current in this winding only at normal speeds.

The bearings are of the ball-seated type supplied with oil from the ship's pressure system and are held in position by steel endshields bolted to the stator frame. The bearing housings with the bearings are adjustable for centering the rotor in the stator frame so as to obtain a uniform air gap.

Over the top half of the motor frame is fastened a hood connected to the ventilating ducts. Two fans driven by direct-current motors and mounted in the hood draw air from the engine room up through the motor and force it through the ducts to the deck.

The specified requirements for driving the *New Mexico* propellers called for 26,500 h.p. at 161 revolutions per min. corresponding to 21 knots ship speed, and 8,350 h.p. at 112 revolutions per min. for cruising at 15 knots.

The motors were wound to operate with either 24 or 36 poles with an output of 6,700 h.p. at 4,000 volts on the 24-pole connection and 2,050 h.p. at 2,800 volts on the 36-pole connection, with an overload capacity of 8,375 h.p. at 172 r.p.m.

At speeds from 8 to 15 knots, the four motors are operated on the 36-pole connection from one generator with its winding connected in parallel, the switching being so arranged that either generator can be used. The variation of speed is obtained by steam control on the turbine-generator.

From 15 to 17 knots, the motors are thrown over to the 24-pole connection, still using only one generator. Above 17 knots, two generators are used, connected in two squares. The two motors and generator on the starboard side and the two motors and generator on the port side are connected together and each set operated as separate units.

For reversing, the 36-pole connection only is used. When the motor is running on the 36-pole connection one phase is reversed. If operating on 24-poles, the connections are changed over to 36 poles and reversed.

During the trial run a test of this reversal was made with the boat running at a speed of 21.25 knots. The motors were reversed and the screw was brought up to full-speed astern on the 36-pole connection (two thirds of the forward speed) in 20 seconds; 12 seconds of this time being used in switching.

The official trials on the driving equipment of the *New Mexico* were made December 16-18, 1918. Runs were made at various speeds from 7.32 knots to 21.31 knots to establish points for the standardization curve.

It developed that due principally to overloading, which increased the displacement by over 1,000 tons, the power required to drive was 29,100 h.p. at 161 r.p.m. instead of 26,500 h.p. at a screw speed of 166 r.p.m.

A four-hour endurance run under full power at 21.25 knots, requiring 31,000 h.p. at 170 revolutions of the propeller was made, followed by runs at 19, 15 and 10 knots.

Two runs over the course were very interesting. The two inboard propellers were run from one generator with the motors connected 24 poles and with the outboard motors disconnected, allowing the propellers to run free. Another trial was made with the outboard motors driving and the inboard propellers free. In both cases a little over 15 knots speed was obtained. These two trials showed that to drive the boat at the same speed the inboard propellers required 11 per cent. more power than the outboard.

During all the trials the motors were in charge of the ship's engineering force and the entire operation was highly satisfactory; especially so, since the power required to obtain full speed was considerably in excess of what was anticipated.

Fig. 4—A portion of the stator, such as shown in Fig. 3, after the winding coils have been inserted and their ends laced to the insulated steel ring

Minerals and Manufactures in Mesopotamia

LITTLE can be said about minerals in Mesopotamia, for little is known. The prospects of petroleum boring have attracted some attention. Petroleum was formerly imported almost wholly from Russia, but in 1906 Austrian and American low-grade oils obtained a footing and advanced in favor. Oil engines and oil lamps came more and more into use and consumption increased. Just before the war the development of the Anglo-Persian oil promised to monopolize the local market unless petroleum was discovered in considerable quantities in Mesopotamia itself. A belt between Kirkuk and the Persian Gulf is certainly oil-bearing in parts, though production has not been attempted upon any scale. A large portion of this belt lies over the frontier in Persia. There are other belts on the Middle Tigris and on the Euphrates south of Hit, but the economic prospects in both cases are quite uncertain. Coal, lead and iron deposits exist in Northern Mesopotamia, and in the past gold was recovered in Bohtar Valley.

The manufactures of Mesopotamia are few and primitive. Steam machinery was used in the military cloth factory at Baghdad, but the other industries may properly be classed as handicrafts. Milling, tanning, boat-building and brick-making are carried on for native supply, and there are a few luxury trades, such as silk weaving, metal working and the distilling of the spirit called araq from dates. The silk factories of Baghdad are famous, and the cultivation of the silkworm was at one time a flourishing industry. Tanning is a solid industry, though the methods are primitive, and bricks are made all over Mesopotamia. They are either used unburnt or burned in rough wooden kilns. When the Hindia Barrage was constructed the native method of making bricks was found to be the best and cheapest.—*Bd. of Trade J.*

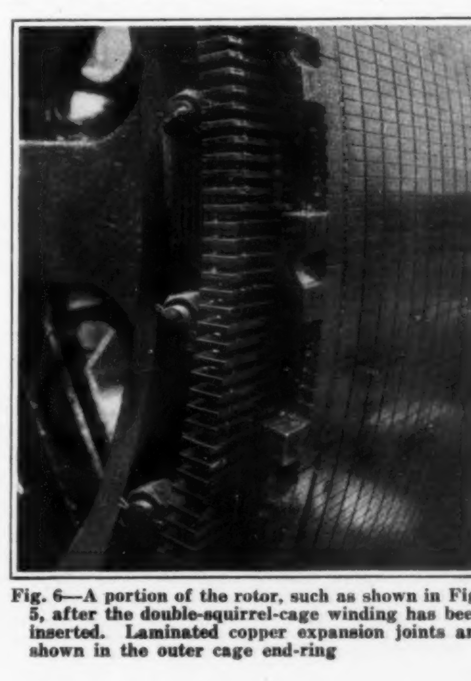


Fig. 6—A portion of the rotor, such as shown in Fig. 5, after the double-squirrel-cage winding has been inserted. Laminated copper expansion joints are shown in the outer cage end-ring

The Continuous-rated Motor and Its Application

An Interpretation of the A. I. E. E. Standardization Rules as Applied to Motors

By L. F. Adams

Nations, various groups within nations, communities, and individuals are and always have been clashing—due, chiefly, to the lack of a common and accurately understood language. The possibility of obtaining such a language is problematical. The world has progressed, however, in various branches of standardization. For centuries the adoption of fixed standards of weights and measures has been of unlimited value. The industrial world, also, has come to realize the benefits of standardization; and during the first part of this century manufacturers began to place their production on a quantity basis thus lowering overhead charges, reducing stocks, simplifying factory methods, tending toward interchangeability of working parts and, most important, giving better service to the purchaser. The individualistic method of standardization, however, resulted in each manufacturer working out his own standards without due regard to those of others and naturally the outcome was as many standards as there were manufacturers. Specifications written along this idea of standardization called for apparatus which was standard for one manufacturer but special with another.

These methods coupled with the keen competition of recent years, created a general desire on the part of all for a common standard. The individualistic method of standardization gave way to collective effort. In the electrical field this latter idea is embodied in the Standardization Rules[1] of the American Institute of Electrical Engineers.

The first step taken by the Institute toward the standardization of electrical apparatus was in 1898, and finally resulted in the acceptance and adoption in 1899 of certain rules coalescing the knowledge up to that time. As the art progressed, it was found necessary from time to time to make revisions and in 1911, under the direction of the Standards Committee of the Institute, there was undertaken a radical revision of the rules. Designing, consulting and operating engineers, scientists, electrical societies, manufacturers, operating companies, users, and other interested parties were consulted. Co-operative action by these parties, representing all branches of the electric power and lighting industry, working toward a common language for the advancement of the electrical industry has given us the present-day specifications or Standardization Rules of the American Institute of Electrical Engineers. These standards, it is worthy to note are substantially the same as those which have also been adopted by the majority of electrical societies that occupy similar poositions in other countries.

The Institute Rules make certain definite recommendations covering electric machinery and apparatus. The following discussion will be confined to an interpretation of these standards as applied to motors and to motor applications.

During the past few years many important improvements have been introduced in motor construction, such as the addition of commutating poles in direct-current machines to improve commutation, better methods of insulating the windings to resist puncture, elimination of excessive hot-spots by the use of internal directive ventilation, etc. These improvements have assured a uniformity of product which formerly would not have been considered within practical limits.

Similar advances have been achieved in the application of motors and the use of the control best suited for any particular purpose. In the pioneer days, motors were usually substituted for other forms of power with but one thought in mind—to have the motor large enough. The vast amount of data now available as to the power requirements of various machines, the large number of well-trained men now engaged in the application of motors, and the unusual desire to do things better today than yesterday, means that motors must now be selected and applied with a greater degree of accuracy than was considered essential in the early days.

It is better to have a motor under-loaded than so heavily loaded that it cannot operate successfully. On the other hand, there is no real advantage in selecting a size and type of motor which is unduly large or expensive for the work. The selection of an unduly large motor means a larger outlay in first cost and a higher yearly charge for power because of the lower average operating efficiency. In the case of alternating-current motors, over-motoring lowers the power-factor, requires a more expensive transmission line and larger generators, and causes poor regulation and greater line losses. Finally, the unused capacity of the motor is without resulting benefit to anyone.

What are the requirements for a successful operating motor? A motor produces torque and speed, the two elements required to drive any load. The load requirements have certain variations in the relations of torque, speed, and time. Consideration must also be given to the operating temperature. We therefore define a successfully operating motor as one of such size and design as will readily start and accelerate any reasonable load for which the driven machine may be called upon to sustain, carry any reasonable overload that may be imposed on the machine, and be capable of carrying the normal load for the period of time required without exceeding a temperature of 90 deg. C. as measured by thermometer.

The first point to consider in the selection of a motor is the starting and accelerating torque. For convenience the starting torque or turning movement of a motor is frequently spoken of in terms full-load torque. For greater accuracy, it is obviously better to use the actual torque developed by the motor at standstill expressed in pound-feet. After the starting torque requirements of the driven machine have been determined, the ratio of starting torque to normal torque should be noted. The ratio, if relatively large, indicates that a compound- or series-wound direct-current motor will be preferable to a shunt-wound machine, or that a slip-ring or high-resistance rotor alternating-current motor should be selected in preference to the standard squirrel-cage motor. Substantially the same method may be used for services requiring very frequent starting. Careful consideration of the starting and accelerating torques frequently permits the selection of a motor of smaller horsepower rating than would otherwise be employed.

The next question is one of peak load. This is usually expressed as a percentage of full-load torque. Here, too, it is better to express this torque in pounds at one-foot radius as this expression eliminates the full-load speed which is variable. Ample margin must be allowed between the requirements of the driven machine and the maximum torque developed by the motor. The maximum running torque which the motor will deliver without undue drop in speed is usually of greater importance than the maximum horsepower output, because in many applications a slight drop in speed on the peaks is advantageous for the inertia or fly-wheel effect in the driven machines assists in carrying the load over that peak.

Another point of interest in the selection of a motor is the horse-power rating. This will be largely a measure of the motor's ability to do the required work for the specified period without exceeding the safe heating limits or violating other requirements of successful operation, such as good commutation.

Heating in motors is primarily of interest only as it affects the life of insulation. The heating standard must be in the form of a limiting temperature, this limit to be sufficiently low that insulation continuously subjected thereto will not deteriorate, in so far as its insulating qualities are concerned. Evidently the logical upper limit should be based on the ultimate temperature at which the motor is to be operated, since it is above this that the insulation begins to weaken. After careful investigation, supported by tests, and in the light of practical experience, the American Institute of Electrical Engineers has set a temperature 5 degrees C. above that of boiling water, i. e., 105°, as a conservative and safe limit for the temperature at which treated fibrous insulation can be used without deterioration. The question arises: Would insulation last longer at a lower temperature? Experience indicates a negative answer. This is to be expected, because even the highest permitted temperature is well below the danger zone. The American Institute of Electrical Engineers in its Standardization Rules, Section 302, states:

"There does not appear to be any advantage in operating at lower temperatures than the safe limits, so far as the life of the insulation is concerned. Insulation may break down from various causes, and when these breakdowns occur it is not usually due to the temperature at which the insulation has been operated, provided the safe limits have not been exceeded."

Having established a suitable upper limit, the next step was the selection of a conservative standard for the cooling medium, or surrounding air temperature, or as it is called in the Institute rules, the "ambient temperature." The value settled upon by the Institute is 40°. In a building this represents an extraordinarily hot day or a very highly heated room for ordinary industrial purposes. It is a temperature approached in all parts of the temperate zone at some time during the year. It is improbable that the average standard motor will normally be required to operate in temperatures as high as 40° for any considerable period of time. For all except the hot days of summer, 21° very closely represents the average mean temperature. Therefore, under normal conditions, motors will seldom operate under as high an ambient temperature as has been proposed, and the value selected is consequently very conservative. Incidentally, in the international conferences on standardization previous to 1914, practically all other electrical societies agreed in recommending 40° as the ambient temperature, but two countries of northern Europe held out for the less conservative ambient temperature of 35°. There are places where conditions are unusual, where the ambient temperature will be higher than 40°. It is evident that such cases should be treated as out of the ordinary, and special motors designed to meet these conditions. It will be recalled that the former ambient temperature was 25°, corresponding not to maximum conditions, but to average conditions.

From what has preceded it is evident that the motor manufacturer in following the Institute standards can design his motor for any temperature rise which, based on an ambient temperature of 40°, will not exceed 105°, i. e., 65 degrees' rise. It should be borne in mind, however, that the temperatures so far used are the external or observable temperatures of the motor and no allowance has been made for the greater heating of the interior and inaccessible parts. It is very difficult to measure internal temperature by ordinary thermometers, and thus the ultimate temperature of motors or the actual temperature rise is arrived at by assuming that the hottest spot in any part of a well-designed motor will have a temperature not more than a certain definite number of degrees above that of the observable temperature of the same part. The Institute's allowance for the difference is 15 degrees C. for open-type motors. This would apply to thermometer readings for ultimate as well as for temperature rises. In other words, the ultimate observable temperature is 90° for treated fibrous materials or a temperature rise of 50 degrees C. above ambient temperature. On totally enclosed motors there is less difference between the hottest spot and the observable temperature so that 10 degrees is a fair allowance for enclosed motors. Therefore, the observable temperature rise permitted for open motors is 50 degrees, and for totally enclosed motors, 55 degrees. While in some designs the permissible temperature rise is decidedly the limiting feature, in other designs the requirements of other conditions will result in a lower temperature rise.

It might appear that a motor which has a temperature rise of 40 degrees will have a longer life than one designed for 50 degrees. As previously pointed out, this is not true because the limit adopted by the Institute for the ultimate temperature is well below that point at which deterioration of the insulation will take place. The situation in this case is roughly analogous to the amount of heat required to produce steam. If the quantity of heat is such that the temperature of water never exceeds 90° no matter how long it is applied, no steam will result because the water has not reached the boiling point. In a like manner deterioration in insulation will not occur until its critical point, analogous to the 100° C. for boiling water, is reached.

In case the ambient temperature is under 40°—say 20°—it might seem that the motor could be operated at a greater temperature rise. This is possible in some cases but a very dangerous policy and the Institute rules do not sanction such loads as shall occasion in the insulation a temperature rise in excess of 50 degrees C. This is a matter of such importance as to justify reproducing from the Institute rules the text of section 305A, which follows.

"305A. Whatever may be the ambient temperature when the machine is in service, the limits of the maximum observable temperature or of temperature rise specified in the rules should not be exceeded in ser-

[1] Latest edition, revised 1918.

vice; for, if the maximum temperature be exceeded, the insulation may be endangered, and if the rise be exceeded, the excess load may lead to injury, by exceeding limits other than those of temperature; such as commutation, stalling load and mechanical strength. For similar reasons, loads in excess of the rating should not be taken from a machine."

With reference to horse-power rating, the Institute has adopted two distinct ratings—one a continuous rating,[2] the other a short-time rating. The meeting of the first is self-evident. The second will be reviewed. It is, briefly, the quivalent output which a motor can deliver for a specified time, such as during 5, 10, 15, 30, 60 or 120 minutes without exceeding a temperature rise of 50 degrees C., provided that, after each run and before starting on the next run, the motor be allowed to cool to within 5 degrees of the ambient temperature. It is also understood that the motor must operate without violating the requirements of successful operation, such as commutation, sufficient starting and maximum torque, suitable mechanical strength, etc. The short-time rating is primarily a method of expressing a thermal equivalent. For example, motors built to operate valves are frequently given a five-minute short-time horse power rating because the operations are normally intermittent and the principal requirements are with reference to mechanical strength, torque and commutation. Crane motors are similarly rated on an equivalent 30-minute basis—since crane motors are operated for longer periods of time than valve motors, although somewhat similar torque characteristics are required. Machine tools, compressors, etc., are frequently rated on a 60- or 120-minute basis, as the period of operation and the duty cycle of the load is such as to make this a close heating equivalent. A machine tool, for example, might be operated for a longer period than specified, but the periods of heavy load and light load must be such that the ultimate heating of the motor will be closely equivalent to the rated horse power for the time stated.

It sometimes happens that some certain requirements may prove a limiting factor in rating a motor, with the result that all the other factors have an unnecessary margin between these values and those recognized as safe standards. Where heating is the limiting factor in the rating or selection of a motor, the horse power rating may be said to represent simply the equivalent load which produces the same heating as would accrue under full normal load in continuous operation. Under these conditions, a 10-h.p. motor which will develop 10 h.p. for the period of time specified without exceeding the predetermined safe heating limits, or it will carry a varying load which will result in the same or lower ultimate temperature for the period in question. As an example, consider a 10-h.p. continuous-rated motor. Suppose a duty cycle of 9.5 h.p., 90 per cent. of the time is to be imposed on this motor; the other ten per cent. to consist of momentary loads of 13 h.p. and under-loads of 3 to 7 h.p. The heating effect on the motor due to this duty cycle would be about the same as if 10 h.p. was delivered continuously. It should be borne in mind, however, that the variations of current, rather than the actual variations of mechanical load, must be used in determining the heating equivalent. It should also be noted that while a 10-h.p. continuous-rated motor would meet the heating limitations it would not be satisfactory unless the starting and maximum running torque available were ample to meet the starting and running overloads imposed on the motor, and that successful commutations should not be exceeded.

The capacity and rating of the machine although frequently used interchangeably are not synonymous terms, according to the Institute. The capacity of the machine is the maximum output which it can successfully deliver for a stated period. The rating of the machine is the output stamped on the name plate. The maximum limit for this rating is the capacity of the machine. There is no minimum limit.

The purchaser is usually interested in knowing all the facts about the possibilities of the machine that he is buying; i. e., the capacity of the machine consistent with the requirements of starting torque, maximum running torque, and similar factors. This logically means that the name-plate rating stated in the accepted even ratings should closely correspond with the capacity rating. Such a rating has been referred to as a continuous or 50-degree rating. Possibly the term capacity rating, within the limits above specified is the most descriptive.

It is obvious that the system which has been widely followed in the past, of giving a normal continuous rating with 25 per cent. overload for two hours, is not a capacity but a fractional rating, and that it represents but one form of duty cycle. Under this method of rating, a 10-h.p. motor will carry 10 h.p. continuously with a temperature rise of 40 degrees and at any time during such operation will carry 12½ h.p. for two hours with a temperature rise of 55 degrees. The temperature rise in these few hours is only a few degrees less than the ultimate temperature which will be attained in eight or ten hours. Consequently, the capacity of such a machine (providing the rating does not under or over state the possibility of the machine) would be about 11⅜ h.p. contiuously or a short-time rating, for 30 minutes, of approximately 15 h.p. This example illustrates that a continuous or capacity rated motor is classed conservatively with reference to heating, since the temperature rise for such an open motor is limited to 50 degrees C. Whereas the temperature rise on a 25 per cent. over-loaded motor is five degrees higher, i. e., 55 degrees.

It must not be overlooked, however, that the intent of the Institute rules is not to require a 50-degree rise but to fix it as a limit for good engineering practice. Designing engineers have long recognized that a temperature rise of 35 degrees in itself was absurdly low, but the object in operating at such low temperature, measured on a part of the motor accessible for the application of a thermometer, was simply to protect the motor in the hot spots where the temperature could not be measured. It had been found by experience that there were hotter parts in the motor than were indicated by thermometer readings. For this reason the exposed parts of the winding not infrequently showed, by thermometer, comparatively small temperature rises of 25 to 35 degrees. Therefore, because the temperature rise was so small, it became the fashion to call for 35 degrees rise motors and no doubt the users never knew the real meaning of such low temperatures. Improvements in insulating material, more modern methods of preparing and applying the insulation, together with the knowledge of hot spots gained for tests and experience have contributed to the Institute recognizing 50 degrees as being the safe upper limit. The rules do not, however, require the motors to be so designed as to actually have this temperature rise. Without doubt, designing engineers will retain a safe margin below 50 degrees rise in the continuous-rated motors.

Other factors will also enter to increase this margin of safety. Usually the ambient temperature will be below 40° C. thereby insuring additional safety. Many motors are running today shamefully underloaded and it is to be expected that numerous applications in the future may be at less than the rated load of the motor although it is hoped that the universal disposition to underload will be overcome to a great extent in applying continuous-rated motors. Analyses made by various power companies have indicated that motors are from 20 to 25 per cent. larger than necessary causing the installation of excess transformer capacity and running up investment costs. Numerous motors are driving a number of machines each having its own duty cycle(such as a machine shop) and investigations have shown that in most applications of group drive, as well as in some cases of individual drive, the demand-factor is less than 100 per cent. Evidently such operation will also increase the margin of safety.

Compare the factor of safety of a motor rated in the old way with that of a motor rated in the new. Was the purchaser any better off? No, because the intended margin was not sufficiently definite. A motor of a certain rating with a certain overload guarantee gives much less idea what can be obtained from the machine than a motor rated on the continuous basis. By the old method a motor was capable of carrying 25 per cent. overload. If the load is steady and there is no overload, 25 per cent. of the possible output of the motor is wasted and the motor is larger than necessary. If it happens that the average load, equal to the rated load, fluctuates up or down ten per cent. there still remains an unnecessary margin of 15 per cent. If the load varies 50 or 100 per cent., the margin of 25 per cent. is worthless and the motor would in all probability burn out. To drive a load requires a certain maximum horse-power output. Under the old method of determining the size of a motor, it was customary to deduct 25 per cent. from the maximum output required by the machine the motor was to drive and thus arrive at the normal rating of the motor. The new method of rating simplifies the determination by omitting the 25 per cent. overload, which is not really overload, and merely stating the maximum load is so much and therefore the motor is rated at that load.

This new and simplified method of rating places on the purchaser the burden of determining the appropriate margin to be provided. The industry is far enough advanced so that the users are capable of selecting their own margin. The application engineers of today are fully conversant with the diversified requirements of the industry, so that they will have no difficulty in selecting the proper motor for each specific case. There is no excuse for guessing at the duty a motor must fulfill. Twenty years of education should have taught the user how to make allowance for the conditions he has to meet. The new method of rating assists both the seller and the buyer by defining more completely the capability of the motor.

Some confusion exists due to the impression that continuous-rated motors will not stand any overload. The motors are guaranteed to stand 50 per cent. momentary overload but they are not guaranteed for any overloads which in heating effect are equivalent to greater than their rated output, i. e., that will cause the motor to exceed a 50-degree rise at any time. In case a motor is subjected to peak loads in excess of the ordinary load and the peak endures for more than a short time, it must be included in the rating. If, however, the peak load lasts for brief periods only, the rating must be sufficiently above the ordinary load to give a continuous thermal equivalent to that required on the brief peak loads without exceeding the permissible temperature limits. From the explanation of the short-time rating it is obvious that the machine will actually carry overloads within the maximum-torque capacity of the machine, but the heating equivalent must be within the limits specified or the motor will not be used within the conditions specified in the guarantee.

It is common practice to rate generators on a continuous basis. During the past ten years, such generators, particularly those for connection to steam or water turbines or gas engines, have been purchased very generally on the basis of a 50-degree rise. The tendency is to raise the machine at the highest point it can be operated at safely in continuous service, thus getting the maximum output possible from the investment. In case a margin for overload is desired, it is necessary to increase the rating of the machine so that the name plate rating equals the maximum load desired. However, transactions arise where it is necessary to rate the generators on a 40-degree basis and in these instances the rating is taken as 83 1/3 per cent. of the rating as a continuous-rated machine.

In this same manner it will be possible to tell the capabilities of a continuous-rated motor operating on a 40-degree basis. For example, a 10-h.p. continuous-rated motor will without change operate successfully as a 8.33-h.p., 40-degree motor and as such will be capable of sustaining an overload up to 10 h.p. with 50-degree rise. This is a scientificly correct method and the only equitable one for obtaining a 40-degree rating from a continuous-rated motor. The objection is that when applied to the continuous-rated motor in standard ratings it gives odd ratings instead of the even ratings to which we are accustomed. However, it is not necessary to place the old rating on the name plate. All motors sold today have a name plate showing, among other factors, the horsepower and corresponding temperature rise. Therefore, mark all name plates with the continuous rating and let it be universally understood that the 40-degree rating is 83 1/3 per cent. of the name plate rating of a continuous-rated motor.

Another method of obtaining the 40-degree rating from the continuous-rated motor is to "derate" to the next even rating. This means a 10-h.p. continuous-rated motor becomes a 7½ h.p., 40-degree motor. Following this method through the line of even ratings gives ratios of 66, 75, 80, or 83 per cent. It is quite evident that his is not the right method of procedure, as at a 40-degree rating the motor contains more material than is necessary to justify the designated rating. Such a system of rating is entirely wrong as it is a direct blow at the conservation of material—recently, a very important matter.

Under the new system, the continuous-rating system, the purchaser will know exactly what he is getting and pay for that only. Just a little thought will enable the purchaser, his engineers, or the application engineer to select the proper size and type of motor. In the transition period, however, it should be realized when applying these motors it is particularly unwise to assume that because a 10-h.p. motor with 25 per cent. overload for two hours did the work, a motor of the same continuous capacity will do the same work. It may or may not, depending entirely upon the starting and maximum load requirements and the heating equivalent of the cycle of duty, but it should be fully realized that the motor will carry its rated load continuously with as great a factor of safety as will a

[2]Throughout the remainder of this article, "continuous rating" will mean a motor that will operate continuously without exceeding a temperature rise of 50 degrees C.

motor guaranteed to carry 25 per cent. overload for two hours, and it will have equally long life and be equally reliable.

Primarily, the manufacturer must make a safe motor for a specified service. The continuous rating and the 50-degree rise proposed is simply a method of stating more clearly and more definitely than ever before just what the motors will do and giving the purchaser the maximum benefit of the material of which the motor is built. The difficulty which some have experienced in facing this new system is chiefly a mental one, for the same factors as formerly will have to be taken into consideration and the purchaser must place before the manufacturer the conditions under which the motors will be required to operate in the same way that he does at present. After all, the motor and not the name plate is to be operated.

The Chemistry of Laundering

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common use, being cheap and quite satisfactory if added quantitatively. In another process the water is filtered through sandy sodium silico-aluminate, or permutite, an artificial zeolite. By double decomposition with the calcium, magnesium and iron salts, this is converted into the respective permutites, which are of course unfit for further use as a filterant. But a ten per cent. aqueous solution of common salt of sufficient depth to cover the permutite over night, after twelve hours' use of the latter, restores the original sodium permutite. The reaction is a reversible one and advantage is taken of the concentration factor in displacing the equilibrium in one direction or the other. Under this treatment the permutite will last for twenty years.

After whatever treatment is used, the softened water must be nearly neutral for alkalinity; else rinsings will be prolonged, acid consumption will be increased in neutralization, the blue may set unevenly, and the starch may be converted into yellow decomposition products during ironing. Likewise, the softened water must be free from any large concentration of sodium salts, otherwise sodium-soap will be "salted out."

The function of the hydroxyl ion from the added alkali in soap dispersion is a manifold one. It saponifies the grease and thus gets it into solution; it increases the solubility of albuminous substances; it lowers the surface tension of the soap solution; it increases the detergent powers of the soap; it neutralizes the hydrogen ion component of soiled materials. All this is well known; in addition, this ion performs certain duties which have not heretofore been recognized, but which are established by experimental research in the author's laboratory which will soon be published. It increases the stability of both the soap dispersoid and the water-grease emulsion; it increases the osmotic pressure of the solution; and it increases the degree of dispersion of the colloidal soap.

Since the effectiveness of the weak alkalis in use is a function of the available alkalinity as a result of hydrolysis, it has been found in order to calculate the ratios of available Na_2O. Taking the efficiency of Na_2CO_3 as 100, it is found that that of $Na_2CO_3.10H_2O$ is 84; of $Na_3PO_4.12H_2O$ is 42; of $Na_2B_4O_7.10H_2O$ is 27.

Sodium oleate is much more soluble than the respective sodium palmitate or stearate, lowers the surface tension to a greater extent, is more highly dispersed, and produces a greater osmotic pressure. The oleate soap therefore has greater detergent power. Drop method determinations of the surface tensions confirm this.

A three-dimensional analytic model showing the relations between soap concentration, hydroxyl ion concentration, and drop number has been constructed. It shows a gradual and direct increase in the cleansing power, with corresponding simultaneous increases in the concentrations of both soap and alkali up to a definite limit, which is never exceeded in laundry practice.

SOAP ADULTERANTS.

Among the adulterants of soaps and sodas must be mentioned sodium silicate, caustic soda and resin. The first weakens, loosens and separates the fiber, and renders it brittle; this follows as a result of the presence of OH from hydrolysis, and the deposition of H_4SiO_4. The caustic soda causes yellow casts of oxycellulose, roughens the thread, diminishes the tensile strength, and leads to excessive lint formation; this may be attributed to the presence of the hydroxyl. Finally, the resin causes yellow casts, due to the resin acids that settle in the fibers. Other adulterants which might be mentioned are peroxides, perborates, clay, chalk, gelatine, boric and salicylic acids, sodium sulfate, alkaline carbonates. These lead to depreciation of the textile fiber to a less marked extent than the three to which special place is given above.

CONCLUSION.

All this may be summarized in the statement that an analysis of the physical and chemical criteria in the washing operations reveals the indispensability of proper scientific control. The launderer's experience when he was not thus guided accumulated slowly and at great cost to society. The factors interrelated with modern laundering show that scientific truth and prospective research are the ultimate recourses of the launderer for maximum efficiency in the plant and minimum cost, both monetary and in reduced wearing qualities, to the community. The patrons' interests and rights demand such low average cost in the face of scientific possibility today that the launderer's slogan must be "Superior Service with Science."

The Light-Giving Power of the Stars

(*Continued from page 395*)

magnitude. On this scale the sun is ordinarily assumed to be of the -26.5 magnitude. In general the difference in light-giving power of two objects is represented by the equation

$$(100)^{\frac{x}{5}} = L$$

where x represents the change in magnitude due to the difference in light L.

Applying this equation to the increase in light due to placing any star of known parallax so that its distance from the earth is the same as that of the sun, the increase in star magnitude is expressed by

$$(100)^{\frac{x}{5}} = \left(\frac{206265}{p}\right)^2$$

or in a logarithmic form

$$x = 26.6 - 5 \log p$$

or in the case of Capella

$$x = 26.6 + 5.5 = 32.1$$

The present magnitude of Capella is 0.2, therefore its new magnitude would be -31.9 or 5.4 magnitudes brighter than the sun. But $(100)^{\frac{5.4}{5}}$ equals 145 which agrees with the results given in a preceding paragraph within the variation due to a difference of less than 0."01 in the assumed value of the parallax.

This formula may be used to compare the light of a variety of stars with that of the sun, as follows:

Name.	Magnitude.	Parallax	Light compared to sun.
Sirius	—1.7	0.37	36
Vega	0.1	0.08	145
Alpha Centauri	0.2	0.75	1.5
Capella	0.2	0.08	133
Arcturus	0.3	0.03	832
Procyon	0.5	0.33	5.8
Altair	0.8	0.23	9.1
Betelgeux	1.0	0.02	1000
Aldebaran	1.1	0.11	30
Pollux	1.3	0.06	83
Fomalhaut	1.3	0.13	17
Regulus	1.4	0.02	692

These values are subject to the uncertainties of the measurement of the parallax and are also only valid in so far as there is no absorption of light in space.

These stars are among the brightest in the heavens and they show a great range in their actual brilliancy which is not at all connected with their apparent brightness as viewed from the earth. Within recent years there have been quite a number of fairly accurate determinations of the fainter stars. It is interesting to note the results from this group. The stars have been chosen at random. In the final column a negative result indicates that the sun is brighter than the star in the ratio given.

Name.	Magnitude.	Parallax	Light.
β Virginis	4	0.11	+ 2.0
ε Eridani	4	0.14	+ 1.3
η Herculis	4	0.15	+ 1.0
70 Ophiuchi	4	0.17	— 1.2
η Cassiopeiae	4	0.18	— 1.3
τ Corona Borealis	5	0.11	— 1.2
θ Serpentis	5	0.12	— 1.5
δ Trianguli	5	0.12	— 1.5
5 Serpentis	5	0.20	— 4.0
Lalande 31055	7	0.11	— 8.0
Cordoba Z. V 243.	8	0.31	— 160
Lalande 21185	8	0.40	— 250
Groombridge 34	9	0.28	— 300

Kapteyn has made somewhat extensive reasearches upon this question of the relative mingling of the brighter and fainter stars in the vicinity of the sun. He has not only used the ordinary values of the parallaxes wherever possible but he has made somewhat extensive use of the "secular" parallax. This lattter is based not upon the movement of the earth around the sun, but upon the movement of the sun through space. This form of parallax cannot be applied to the case of a single star, but is available in the case of a group of stars. As a result of his researches Kapteyn finds that inside a sphere inscribed around the sun with a radius corresponding to the parallax 0."006 we should expect to find:

1 star which was between 100,000 and 10,000 times as bright as the sun.

46 stars which were between 10,000 and 1,000 times as bright as the sun.

1,300 stars which were between 1,000 and 100 times as bright as the sun.

2,200 stars which were between 100 and 10 times as bright as the sun.

140,000 stars which were between 10 and 1 times as bright as the sun.

430,000 stars which were between 1 and 0.1 times as bright as the sun.

650,000 stars which were between 0.1 and 0.01 times as bright as the sun.

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